HAZARDOUS WASTE RESEARCH AND INFORMATION CENTER
State Water Survey Division
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Illinois Department of
Energy and Natural Resources

HWRIC RR 005

SPECIAL WASTE CATEGORIZATION STUDY

VOLUME I

by *K. R. Reddy*
Energy and Environmental Affairs Division
Illinois Department of Energy and Natural Resources

October 1985

FINAL REPORT

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October 1985

Energy and Environmental Affairs Division
Department of Energy and Natural Resources
325 W. Adams Street
Springfield, IL 62706

SPECIAL WASTE
CATEGORIZATION STUDY

Project # HWRIC 007

Principal Investigator: K. R. Reddy

to

Hazardous Waste Research
and Information Center

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ERRATA

"Environmental toxicity" should read "Aquatic toxicity" throughout the report.

This report is printed in two volumes, Volume I is the main report. Volume II contains lists of Illinois RCRA and non-RCRA special wastes, and information on the waste streams evaluated in this report. Volume II is available upon request.

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PREFACE

Pursuant to Public Act 83-1268, the Hazardous Waste Research and Information Center contracted with the Energy and Environmental Affairs Division (EEA) of the Department of Energy and Natural Resources to conduct a research study entitled Special Waste Categorization Study. The primary purpose of the study was to design a system to classify industrial wastes ("special wastes") by the degree of hazard they pose to human health and the environment. EEA staff provided the overall design and management of the study and for the conduct of the following specific components: The analysis of the special waste stream data, the review of regulations pertinent to the management of special wastes in Illinois, and an analysis of alternative hazardous waste taxes. For the development of the classification system, EEA staff provided the conceptual framework and the basic criteria to guide the design, and actively participated in the design of the system. Battelle-Columbus Labs was hired as technical consultants to work on the actual design of the special waste classification system. In addition, Battelle performed an initial test of the system by analyzing a selected group of special waste streams.

Principal members of the project study team included K.R. Reddy and David B. Ramsay from the Department of Energy and Natural Resources and Richard P. Moffa, Jerry D. Wrench, Richard Shank, Barney W. Cornaby and John A. Gurklis of Battelle-Columbus Labs.

In July 1985 the Department made available to interested parties a draft report of the study. Interested parties were requested to submit comments back to the Department. Subsequently, the Department, along with study team members, met with representatives of industry, environmental groups and Illinois EPA officials and presented the study. Written comments that have been received by the Department are presented in Appendix I of this report. As a result of this review, a few changes were made in the preface and to the recommendations on pages E-14, 7-7 and 7-8. When comments in the letters refer to a section of the draft report that was changed, copies of the draft pages are included in the Appendix.

The purpose of the study was to develop a system with a sound scientific basis for classifying Special Wastes according to their degree of hazard. The study did not provide a definitive classification of the Special Waste streams in Illinois. The purpose of analyzing specific waste streams in the context of

this study was to test the ability of the classification system to discriminate among various degrees of hazard. Thus, the study in and of itself, does not provide a basis for deriving new regulations concerning hazardous wastes.

The study assumptions and the opinions expressed in this report are based on the professional judgement of the members of the study team and do not necessarily reflect the official position of the Department of Energy and Natural Resources.

October, 1985

K. R. Reddy, P.E.
Principal Investigator

EXECUTIVE SUMMARY

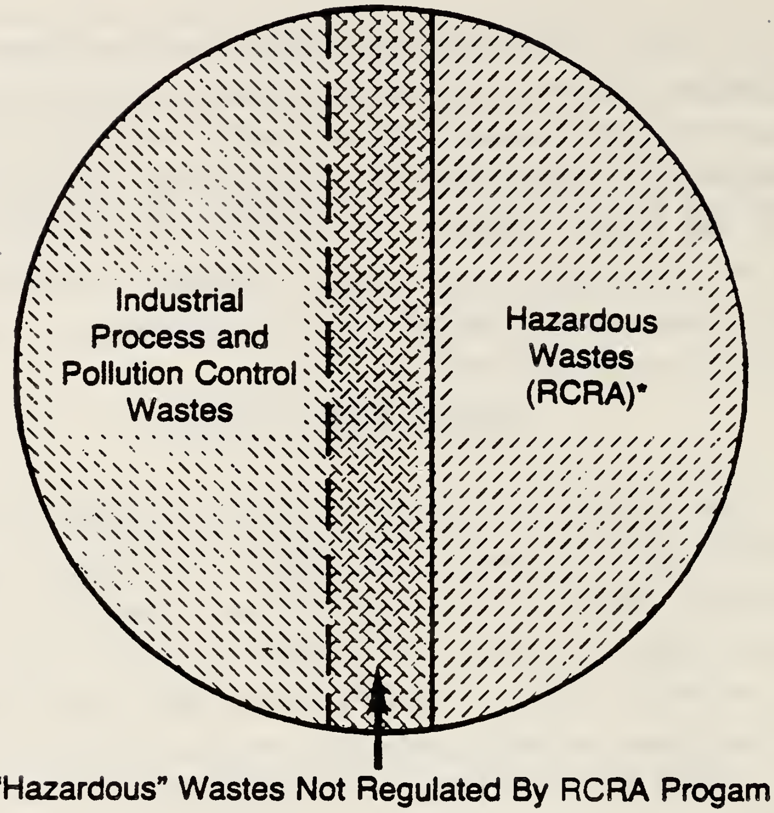
Public Act 83-1268 mandated the Illinois Department of Energy and Natural Resources to conduct a study and develop a classification system for "Special Waste" streams generated in Illinois. The law specifies that the system should be based on the degree of hazard that the waste streams pose to human health and the environment. In addition, the Department was directed to analyze and catalogue various storage, treatment and disposal technologies based on the results of the waste classification system.

What is Special Waste?

In the context of Illinois' solid and hazardous waste regulations, the term Special Waste includes, as a subset, all federally-regulated "hazardous wastes" as well as Illinois-defined "industrial process wastes" and "pollution control wastes." Specifically excluded from Special Wastes are general household wastes, construction and demolition waste, landscape waste, uncontaminated packaging materials or uncontaminated machinery components. Figure E-1 illustrates the relationship of the different waste types to the Special Waste category.

Under Illinois' current environmental regulatory system, all Special Wastes, both hazardous and non-hazardous, have similar permitting requirements for transportation and disposal. One of the major criticisms of the current system is that it does not adequately acknowledge, in a regulatory sense, the differences in health and environmental risks posed by the hazardous and the non-hazardous waste streams. In terms of actual disposal techniques, however, Illinois' regulatory system does distinguish between hazardous wastes, as defined by the federal Resource Conservation Recovery Act (RCRA), and all other Special Wastes. The regulatory requirements for sites that dispose of non-hazardous Special Waste are not as stringent as for sites which dispose of (RCRA) hazardous waste. Municipal landfills may accept non-hazardous Special Waste if this provision is included in the site's operating permit. Alternately the site can obtain a "supplemental permit" which allows the landfill to accept non-hazardous special wastes.

What is Special Waste?



Special Wastes:

- Hazardous Wastes (RCRA)
- Industrial Process Wastes
- Pollution Control Wastes

* **Federal Resource Conservation and Recovery Act**

FIGURE E-1

The Special Waste Issue

In the course of the national hazardous waste debate, there has been much public attention directed at the health effects of wastes generated by the modern industrial economy. To the extent that regulatory bodies reflect public attitudes, it appears to many parties in this dispute that society has lost sight of the complexity and uncertainty regarding the actual danger of the various waste streams. One of the major complaints of the industrial waste generators in Illinois is related to this issue. As a result of Illinois' waste management regulatory system, many industries believe they are being over-regulated.

Based on ENR discussions with the interested parties, the sides in the Special Waste issue can be summarized as follows:

a. The industrial argument: The industries which generate much of the hazardous and non-hazardous Special Wastes in Illinois have accepted stringent regulatory requirements for disposal of RCRA-defined hazardous waste. They feel strongly, however, that Illinois' regulatory system (which regulates non-hazardous Special Waste the same as RCRA hazardous waste) is unreasonable and unnecessary. Their preference would be for a regulated hazardous waste category which would include all special wastes which have hazardous characteristics, a list which they acknowledge will be greater than the RCRA-defined list. In addition, however, many industries would like deregulation of all remaining non-hazardous Special Wastes. Furthermore, the industries are concerned about the public's inability to distinguish between wastes which are dangerous to their health and those which are not dangerous, all of which are currently labeled 'special.' Industrial representatives argue that the term "Special Waste," as currently understood by the public, serves only to cause confusion and tension between industries and the public.

b. The environmentalists' argument: The major concern among environmental groups in Illinois is to promote a state policy which will lead to the reduction in the quantity and hazard of the waste generated. They are interested in promoting the use of waste-reduction and waste-elimination

technologies and to maintain existing waste regulations. The environmental groups have often expressed the view that Illinois allows significant types and quantities of hazardous wastes to go unregulated.

In summary, the results of this study are expected to provide technical information for categorizing various waste streams, based on their relative degree of hazard and possibly provide a basis for proposing new regulations or modifying existing regulations of Special Waste management practices in Illinois.

The Study Approach

The study approach was based on ENR's interpretation of the legislation, as well as conversations with state regulators, regulated companies and environmentalists, and it consisted of the following elements:

° The development of a classification system capable of being used to evaluate the 'degree of hazard' of individual waste streams;

° The analysis of the Special Waste streams in order to determine the availability of data on each individual waste stream, develop criteria to guide the design of the proposed classification system and prepare comprehensive listings of hazardous and non-hazardous Special Waste streams;

° The identification of the 'state-of-the-art' disposal technologies applicable to Illinois' Special Waste streams; and

° Test the proposed classification system by evaluating selected Special Waste streams.

Description of the Classification System

The proposed classification system is based on a three-phased approach. The three phases, depicted in Figure E-2, consist of the Special Waste Screen, the Degree of Hazard Evaluation and the Treatment/Disposal Evaluation.

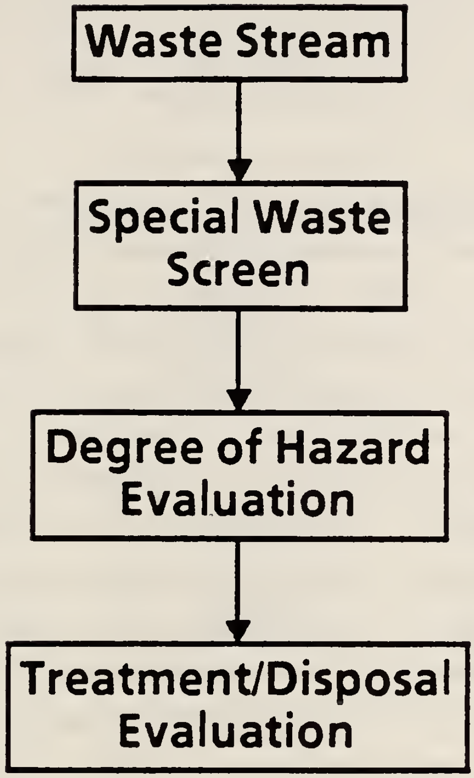


FIGURE E-2 OVERVIEW OF THE WASTE CLASSIFICATION SYSTEM

The outcome of the proposed classification system is an assessment of the degree of hazard posed by a Special Waste for five possible waste characteristics: toxicity, disease, fire, leaching agents and biological characteristics. After a Special Waste has been evaluated for each of these five waste characteristics, then the waste may be considered in the treatment/disposal evaluation. Figure E-3 illustrates the classification system.

The three phases of the classification system are discussed below:

Special Waste Screen

The first phase of the proposed system is the Special Waste screen. This screen is designed to rapidly determine whether a waste stream should be subjected to the more comprehensive degree of hazard evaluation or the waste can be categorized as innocuous. This screen consists of 10 steps and is accomplished by comparing chemical substances in the waste stream to a series of lists, standards, or definitions. These steps are shown in Figure E-4.

The screening evaluation is basically a qualitative evaluation by which the waste components are analyzed for their hazard potential. It does, however, require detailed information about the chemical composition of the wastes. This information is contained in the Special Waste disposal permit application and accompanying chemical analysis, and provides sufficient data to conduct the screening evaluation. The screening process proceeds by comparing the chemical components against specific thresholds or standards. If it exceeds that threshold or standard for that criteria, the waste stream is subjected to the "Degree of Hazard Evaluation." If not, the other chemical components are evaluated. If each component does not exceed the standard for that criteria, then it proceeds to the next step. Thus, the screening evaluation consists of a series of yes/no steps: does it exceed the standard? If no, then it goes on to the next step. For example, if any waste stream component exceeds the minimal standards for toxicity, then the waste stream proceeds to the Degree of Hazard Evaluation. If there are no toxic components, the waste stream would proceed to the next criteria which concerns biological characteristics. If a waste stream goes through the entire screening phase without exceeding any of the standards, it would be designated as a minimal risk waste stream because the standards set for each criteria are set at very conservative levels to ensure that any questionable waste streams would go to the more comprehensive Degree of Hazard Evaluation.

Simplified Schematic Diagram of Special Waste Classification System

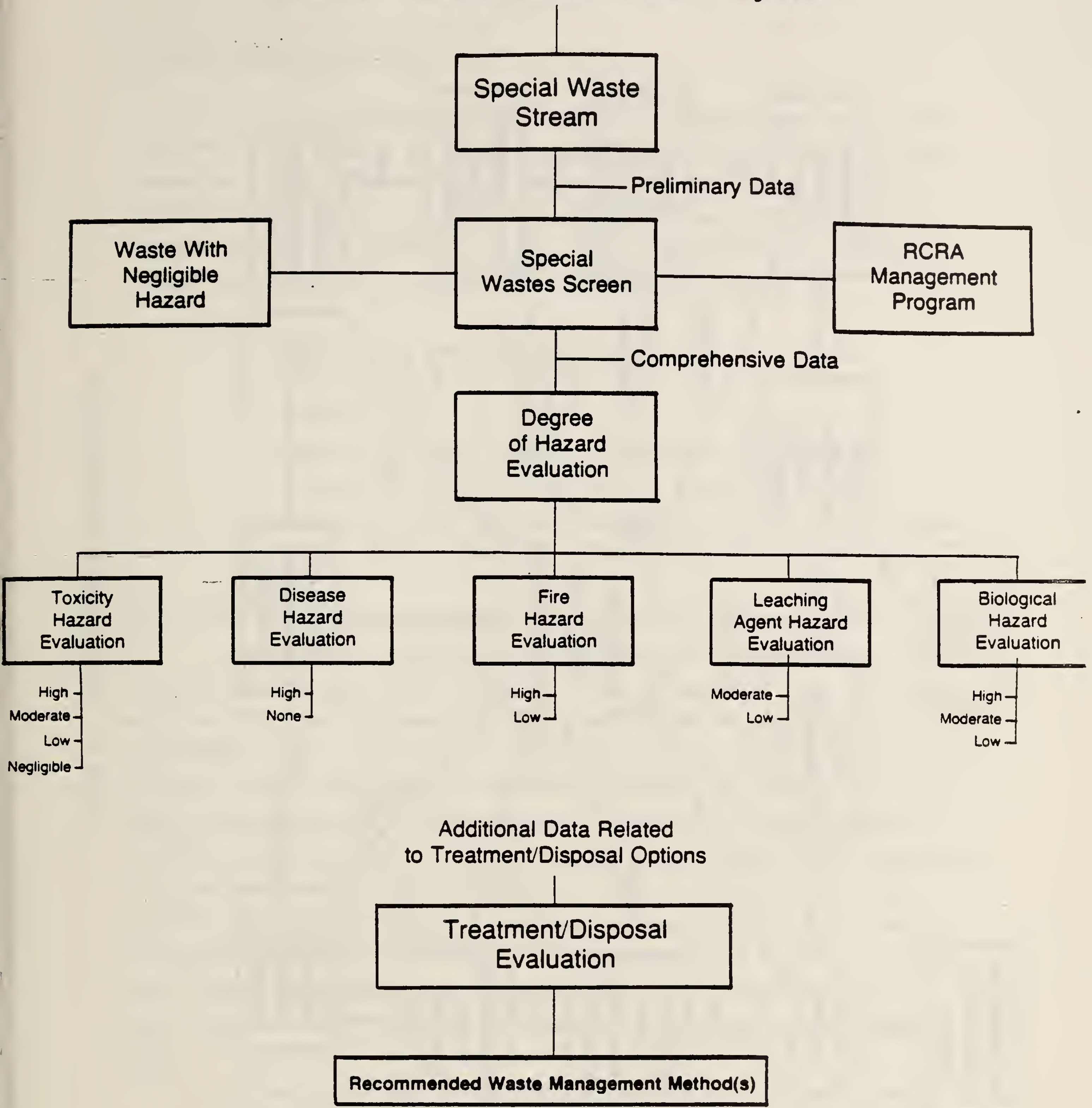


FIGURE E-3

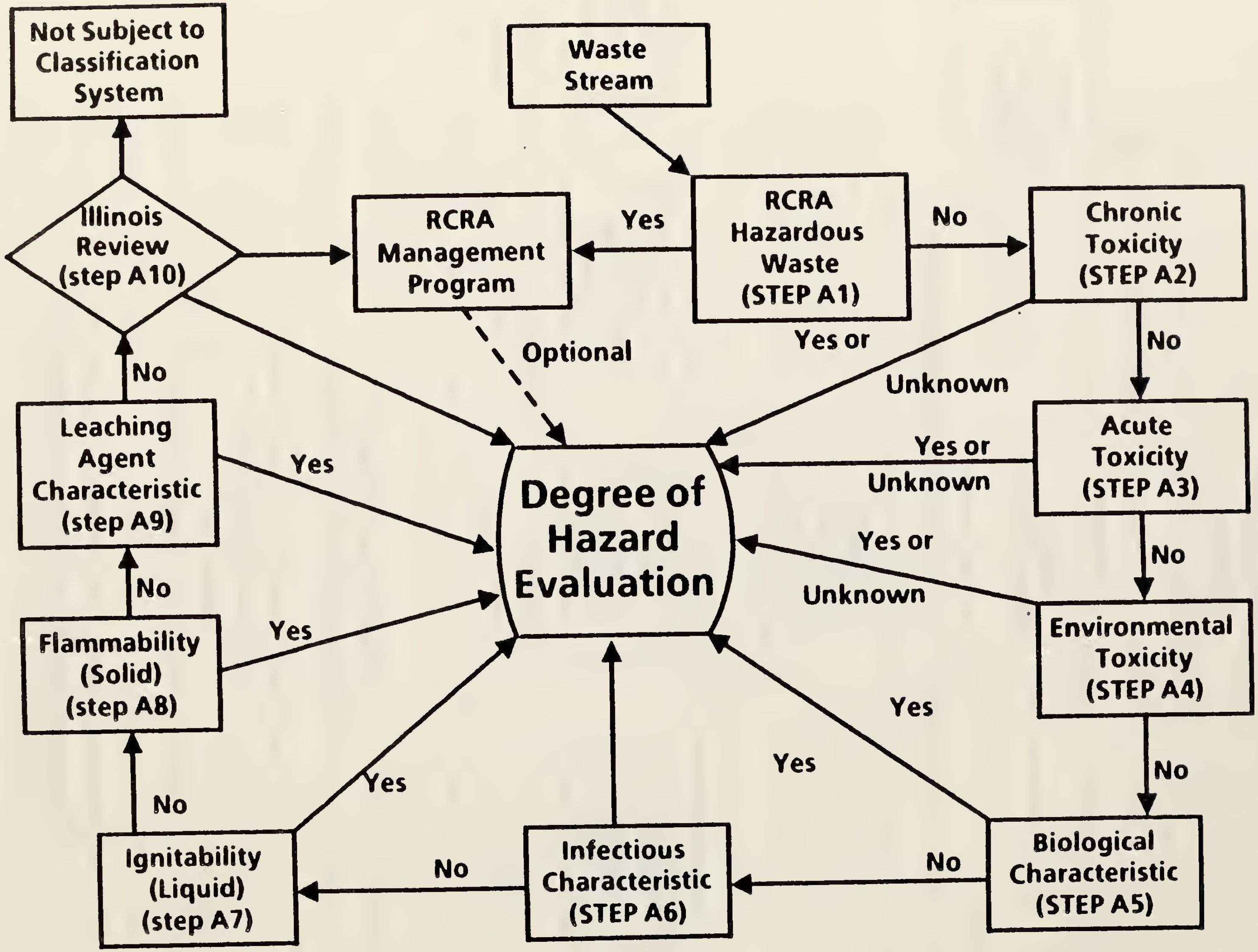


FIGURE E-4 **SPECIAL WASTE SCREEN (STEP A)**

Degree of Hazard Evaluation

If one or more of a waste stream's components exceed any of the standards at any step in the screening process, it goes on to the more comprehensive Degree of Hazard Evaluation. The Degree of Hazard Evaluation requires an evaluation of all of the components found to be potentially hazardous during the screening process. The steps of this comprehensive evaluation consist of an evaluation of the following factors:

1) toxicity and environmental fate,
2) infectiousness,
3) flammability,
4) capacity to cause leaching of hazardous substances and contamination of either surface or groundwater, and
5) capacity to generate a leachate with a high biological oxygen demand (BOD) or generate methane or hydrogen sulfide (gas).

Figure E-5 illustrates the Degree of Hazard Evaluation process phase.

The Degree of Hazard Evaluation places the primary emphasis on toxicity which is evaluated in step 1. It is assumed that it is the toxicity which has the major long-term and significant impact on human health and the environment. This step includes an evaluation of the "environmental fate" of the toxic wastes. The factors examined here concern the tendency of a substance to accumulate in living organisms, to persist or break down into non-toxic components, and to be dissolved by water. These factors may modify the significance of the toxicity factors, taken alone. A decision tree approach, as shown in Figure E-6, was used to combine the toxicity analysis with the environmental fate aspects. The key importance of toxicity can be seen in this figure where the highest toxicity level always receives an overall score of the highest level regardless of the environmental fate level.

Unlike the initial screening step, the data requirements for the Degree of Hazard Evaluation are comprehensive. In order to conduct the Degree of Hazard Evaluation, additional data may sometimes be required beyond

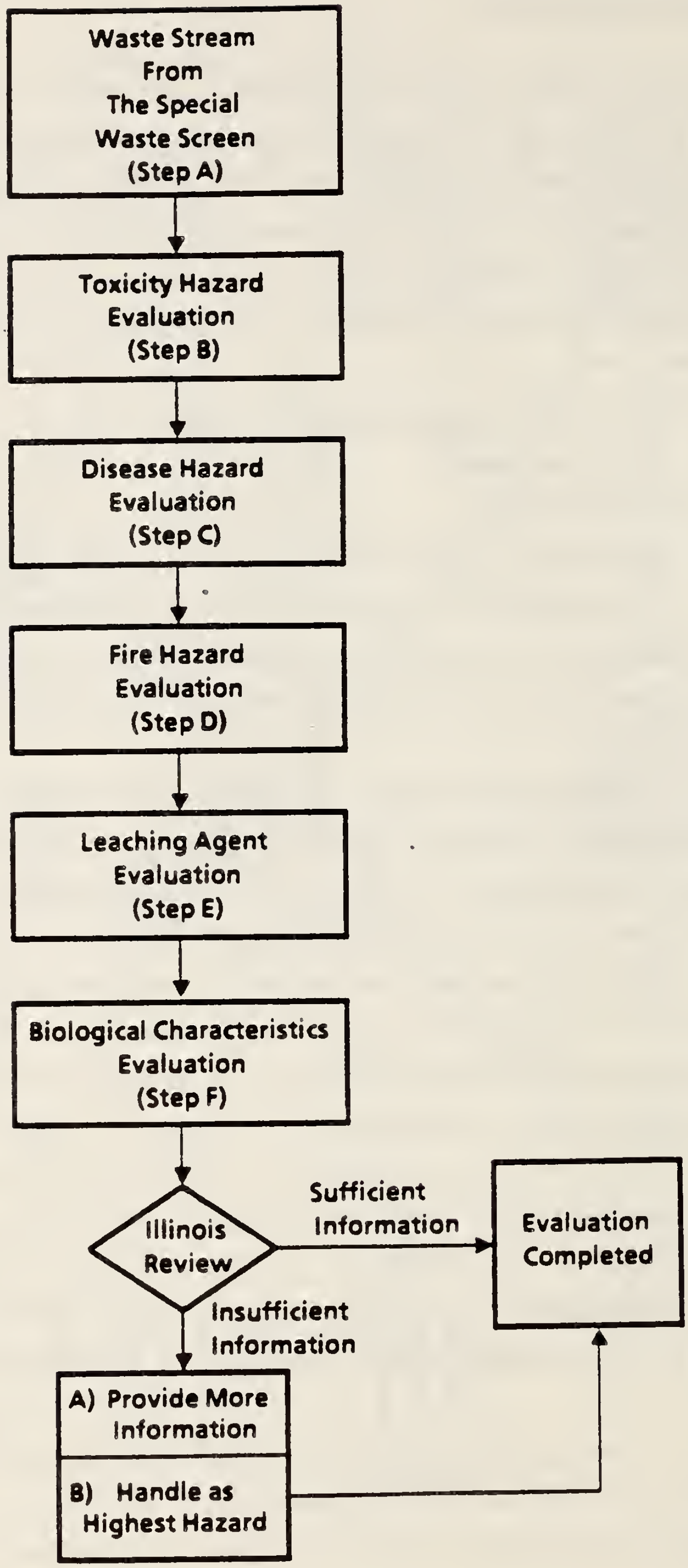


FIGURE E-5 **DEGREE OF HAZARD EVALUATION**

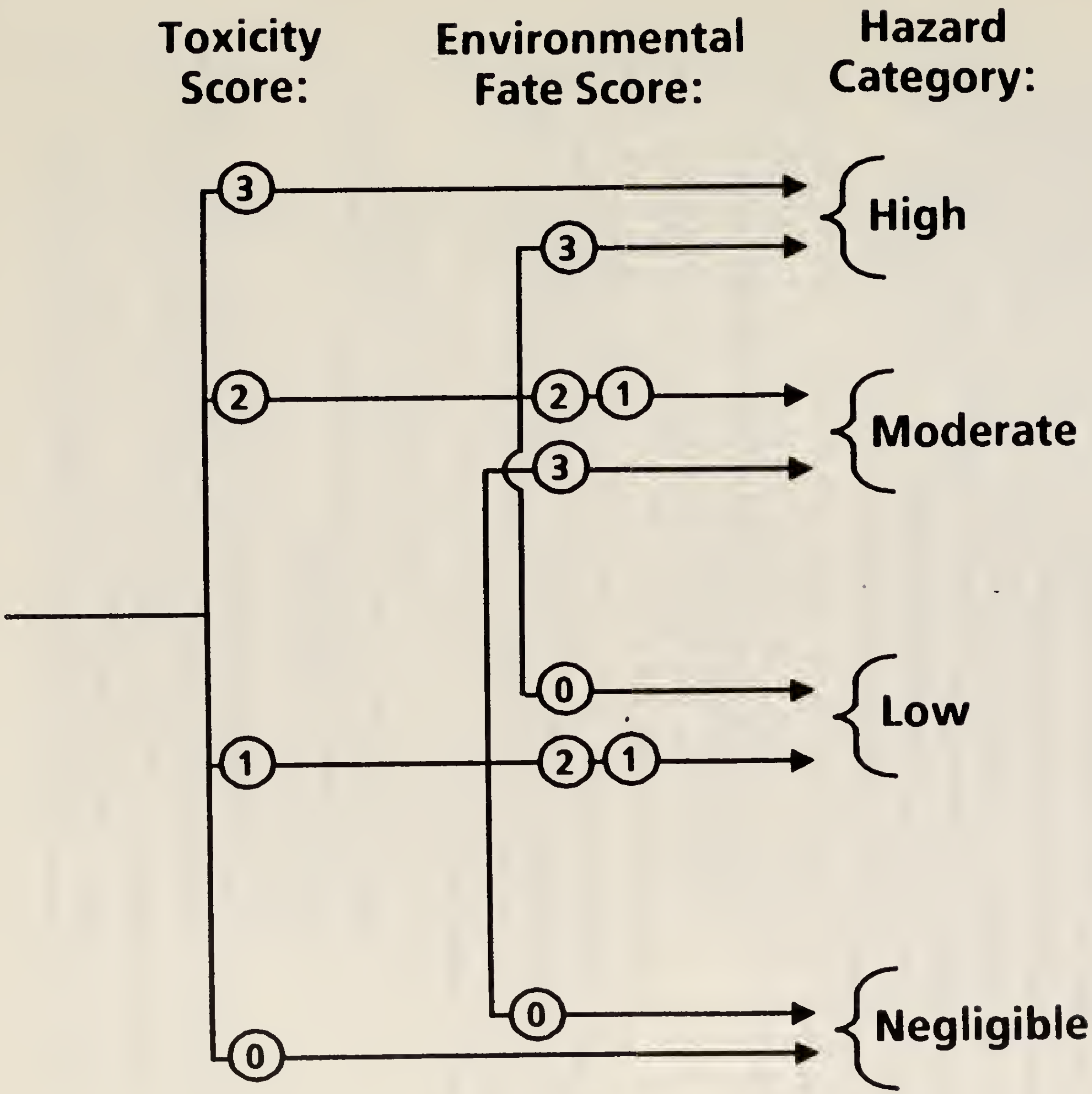


FIGURE E-6 TOXICITY HAZARD CATEGORIZATION GRAPH (STEP B3)

that collected by the IEPA permitting system. This may include information on the five characteristics discussed above as appropriate for each component of the waste stream.

Once a waste stream has been analyzed in the Degree of Hazard Evaluation, it is assigned a weighted score based on its performance in each of the five categories. The score provides an indication of the degree and type of hazard associated with the waste stream under analysis.

Treatment/Disposal Evaluation

The information obtained from the previous two phases provides the basis for the Treatment/Disposal Evaluation. This phase of the evaluation matches waste characteristics with appropriate treatment/disposal technologies. The process relies heavily on the output of the Degree of Hazard Evaluation and on the knowledge of existing treatment/disposal technologies to determine appropriate waste management methods. This component of the system will periodically need to be updated as new technologies are developed.

Testing the Proposed Classification System

The proposed system was used to test 238 out of a total of nearly 6000 waste streams. Of the 238, six were RCRA hazardous wastes. The remaining 232 were selected from non-RCRA Special Wastes. In order to test the classification system, the 238 wastes were selected on the basis of the following criteria:

1. waste streams which have a high rate of generation;
2. waste streams which have high toxicity or high hazardous properties;
3. "low or minimal" toxicity or hazard;
4. waste streams now classified as non-hazardous which have physical chemical properties similar to waste streams now classified as hazardous; and
5. waste streams identified by industrial trade groups.

Of the 238 wastes screened, 237 of them would have been selected for the Degree of Hazard Evaluation, 137 on the basis of known toxic components. Information necessary to complete the screening was unavailable for 100 of the waste streams; therefore, they were selected for the Degree of Hazard Evaluation under the 'lack of information' criterion. Finally, only one waste stream passed through the screen and would have been declared not hazardous.

This result does not mean that the 237 waste streams which were selected for the Degree of Hazard Evaluation were in fact hazardous. Using this classification system, the conclusions for the 137 waste streams resulted from either the existence of at least one known toxic component or the lack of sufficient data. This fact alone, however, does not mean that they were hazardous. It does mean they should have been analyzed more closely. For the 100 streams, the lack of information regarding their characteristics caused them to be directed to the Degree of Hazard Evaluation. Some of them may have been hazardous; some may not have been. Without additional information, the streams cannot be categorized as non-hazardous.

Finally, in order to test the Degree of Hazard Evaluation itself, thirty of the 237 streams were analyzed using the Degree of Hazard procedure outlined above. The selection process was biased to favor the inclusion of waste streams that are relatively more hazardous.

The results of this evaluation are as follows:

1. High degree of hazard - 12 waste streams
2. Moderate degree of hazard - 5 waste streams
3. Low degree of hazard - 3 waste streams
4. Negligible degree of hazard - 7 waste streams
5. Unknown degree of hazard - 3 waste streams

Conclusions

The results of testing the degree of hazard classification system demonstrates that the system does have the ability to discriminate levels of hazard among those Special Waste streams tested. As discussed earlier, among the 30 Special Waste streams subjected to the Degree of Hazard Evaluation all four hazard levels were represented. This result does not allow definitive

conclusions to be made about the total universe of Special Waste streams because neither the 238 nor the 30 waste streams are statistically representative of all Special Wastes.

In the conduct of this study, certain assumptions were necessary. In designing a workable (degree of hazard classification) system, a balance had to be struck between the value of simplicity and the need for complexity. If a system is too simple, it cannot adequately discriminate among the waste streams; if it is too complex, no one will be able to use it in real life situations. Finally, it must be recognized that the classification system is only a tool that provides a framework for decisions regarding the acceptable levels of risk. Science can only go so far. The final decisions must be based in part on the best judgements made by the affected parties in this issue.

Recommendations

If the state is interested in implementing such a classification system, then the following recommendations should be considered:

The state should continue the current level of data requirements for special wastes and insure that such reporting requirements are sufficiently fulfilled in order to provide a basis for an accurate assessment of the waste streams. These data are needed to determine the hazardous properties of special wastes.

The proposed classification system is a workable system. Further refinements are needed with attention to the specific issues and assumptions discussed in this report.

The State should complete the development of this classification system by using it to conduct an evaluation of the degree of hazard of waste streams and examining the economic implications of implementing such a system.

1.0 INTRODUCTION

Public Act 83-1268 mandated the Illinois Department of Energy and Natural Resources to conduct a study and develop a classification system for "Special Waste" streams generated in Illinois. The law specifies that the system should be based on the degree of hazard that the waste streams pose to human health and the environment. In addition, the Department was directed to analyze and catalogue various storage, treatment and disposal technologies based on the results of the waste classification system.

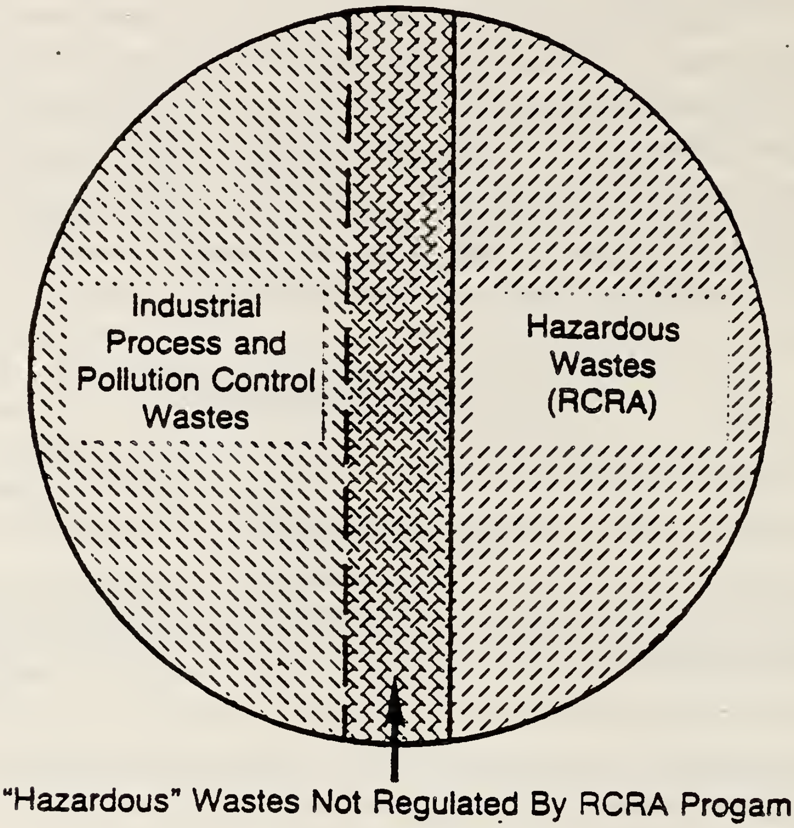
1.1 What is Special Waste

In the context of Illinois' solid and hazardous waste regulations, the term Special Waste includes, as a subset, all federally-regulated "hazardous wastes" as well as Illinois-defined "industrial process wastes" and "pollution control wastes". Specifically excluded from Special Wastes are general household wastes, construction and demolition waste, landscape waste, uncontaminated packaging materials or uncontaminated machinery components. Figure 1-1 illustrates the relationship of the different waste types to the Special Waste category.

1.2 State Regulatory Framework for Special Wastes

As stated before, Special Wastes include hazardous wastes, industrial process wastes, and pollution control wastes. Hazardous wastes are defined by State law to be those regulated under the federal Resource Conservation and Recovery Act (RCRA). Consequently, all hazardous Special Wastes come under RCRA and are managed under the authority delegated to the Illinois EPA by the U.S. EPA. Non-hazardous Special Wastes, that is, pollution control and industrial process wastes are regulated only under State laws and regulations. These regulatory mechanisms include a system of permits and a manifest. A site operator must obtain a special waste stream permit which is also known as waste stream authorization number from the IEPA for each waste stream before it can be accepted at a waste treatment, storage, or disposal site.

What is Special Waste?



Special Wastes:

- Hazardous Wastes (RCRA)
- Industrial Process Wastes
- Pollution Control Wastes

Wastes with Hazardous Properties

The special waste stream permit which is also known as "waste stream authorization number" is issued to a site or facility operator by the Illinois EPA, based on the special waste stream permit application made by the facility operator. This application contains specific information on the waste stream which includes the physical characteristics, chemical composition, the industrial process by which this waste stream is generated. IEPA compares this information with the information on the facility which proposes to accept this waste stream and approves or disapproves the permit application based on the facility's capability to handle this waste stream.

To accept non-hazardous special wastes, a landfill must have 10' clay liner with a permitability of 10^{-7} cm/sec., and a minimum of four monitoring wells, one upstream and three downstream. This requirement is basically the same for a municipal landfill. However, the requirement for the disposal of RCRA hazardous wastes are more stringent. RCRA permitted landfill requires 10' clay liner with a permiability of 10^{-8} cm/sec. Additional requirements are a synthetic liner and a leachate collection system.

A manifest document is required for a transporter, treater, storer, or disposer to accept any Special Wastes. A manifest tracks the movement of wastes from "cradle to grave", that is from the point of generation through its final disposition at the treatment, storage or disposal site. The generator and the final TDS facility are required to return copies of the manifest to the IEPA creating a closed loop, whereby the Agency can ensure that all properly manifested wastes reach their final intended destination. In reality, due to the high volume of documents per year, the IEPA is six to seven months behind in processing the manifest documents. <u>Seventy to eighty percent</u> of the manifests are for non-hazardous Special Wastes and the Agency maintains that processing these documents severely limits its ability to track the hazardous Special Wastes.

The IEPA has two administrative procedures that reduce the regulatory burden of managing Special Wastes. The Agency has recently begun a "generic" permit procedure whereby a single supplemental permit is needed for a hauler to pick up certain wastes such as used oil or solvents from several facilities and to take them to a treatment or recycling facility. Also,

generators of certain innocuous Special Wastes may apply to the Agency to have such wastes removed from the Special Waste category. Off-specification food products such as spoiled mayonnaise or cookies are examples of such wastes. The generator must demonstrate to the IEPA that the waste stream in question does not meet the two basic criteria in the definition. These criteria are that: 1) the waste does not pose a present or potential threat to the environment; and 2) that it does not have inherent qualities that make its disposal in a landfill difficult by normal means.

1.3 Federal Law and Regulations

Non-hazardous Special Wastes are not regulated under federal law. However, recent changes in the Resource Conservation and Recovery Act may have an effect on the regulation of several categories of currently non-hazardous Special Wastes. Under the 1984 RCRA amendments, the federal government is enlarging the scope of RCRA to cover certain types of wastes not formerly defined as hazardous. These include among others, fuels derived from hazardous wastes and used oils and certain dioxin and dibenzofurans containing solvents. In addition, regulations for small quantity generators (100 to 1,000 kilograms per month) will be increasing. Also, the U.S. EPA is directed to remedy the deficiencies in the EP toxicity test as a measure of leaching potential and also to identify additional characteristics of hazardous waste, including measures of toxicity. All of these changes point in the direction of enlarging and refining the RCRA definition of hazardous wastes.

1.4 Pollution Control Board Dockets

The Illinois Pollution Control Board currently has two regulatory initiatives before it: R84-43 Manifesting Non-hazardous Special Wastes, and R84-17 Permit Requirements and Operating Standards for Owners and Operators of Class I and Class II Landfills and for Generators and Haulers of Special Waste.

This study has implications for both of these regulatory dockets. In the manifest proposal, the Illinois EPA has proposed to eliminate part of

the manifest requirements for certain types of non-hazardous Special Wastes. The Agency's proposal would retain the full manifest requirements for PCB's, used oils and asbestos wastes. The reason given to include these particular wastes is that PCB's and asbestos are regulated under the Toxic Substances Control Act (TSCA) and used oils have, from the Agency's experience, been a difficult regulatory problem. The degree of hazard waste classification system could potentially assist the Pollution Control Board or the Agency in deciding what categories of waste should be included in the complete manifest process as it now stands.

The second docket concerns the revision of the formerly titled Chapter 7 and 9 of the PCB solid waste regulations. The current proposal before the Board, which has been submitted by the Illinois State Chamber of Commerce would substantially change the current regulations governing Special Wastes. Again, a clearer and more precise characterization of those Special Wastes by degree of hazard could assist in this modification of the regulations. It may be possible to identify certain categories of innocuous wastes that can essentially be "deregulated." At the same time, there is expected to be certain Special Wastes identified as hazardous that currently fall outside of that definition.

1.5 Summary of Regulations Governing Special Wastes

Under Illinois' current environmental regulatory system, all Special Wastes, both hazardous and non-hazardous, have similar permitting requirements for transportation and disposal. One of the major criticisms of the current system is that it does not adequately acknowledge, in a regulatory sense, the differences in health and environmental risks posed by the hazardous and the non- hazardous waste streams. In terms of actual disposal techniques, however, Illinois' regulatory system does distinguish between hazardous wastes, as defined by the federal Resource Conservation Recovery Act (RCRA), and all other Special Wastes. The regulatory requirements for sites that dispose of non-hazardous Special Waste are not as stringent as for sites which dispose of (RCRA) hazardous waste. Sanitary landfills may accept non-hazardous Special Waste if they monitor the site for possible groundwater contamination.

1.6 The Special Waste Issue

In the course of the national hazardous waste debate, there has been much public attention directed at the health effects of wastes generated by the modern industrial economy. To the extent that regulatory bodies reflect public attitudes, it appears to many parties in this dispute that society has lost sight of the complexity and uncertainty regarding the actual danger of the various waste streams. One of the major complaints of the industrial waste generators in Illinois is related to this issue. As a result of Illinois' waste management regulatory system, many industries believe they are being over-regulated.

Based on ENR discussions with interested parties, the sides in the Special Waste issue can be summarized as follows:

a. The industrial argument: The industries which generate much of the hazardous and non-hazardous Special Wastes in Illinois have accepted stringent regulatory requirements for disposal of RCRA-defined hazardous waste. They feel strongly, however, that Illinois' regulatory system (which regulates non-hazardous Special Waste the same as RCRA hazardous waste) is unreasonable and unnecessary. Their preference would be for a regulated hazardous waste category which would include all Special Wastes which have hazardous characteristics, a list which they acknowledge will be greater than the RCRA-defined list. In addition, however, many industries would like deregulation of all remaining non-hazardous Special Wastes. Furthermore, the industries are concerned about the public's inability to distinguish between wastes which are dangerous to their health and those which are not dangerous, all of which are currently labeled 'special'. Industrial representatives argue that the term "Special Waste" as currently understood by the public, serves only to cause confusion and tension between industries and the public.

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The environmental groups have often expressed the view that Illinois allows significant types and quantities of hazardous wastes to go unregulated.

In summary, the results of this study are expected to provide technical information for categorizing various waste streams, based on their relative degree of hazard and possibly provide a basis for proposing new regulations or modifying existing regulations of Special Waste management practices in Illinois.

1.7 Study Approach

The study approach was based on ENR's interpretation of the legislation, as well as conversations with state regulators, regulated companies and environmentalists, and it consisted of the following elements:

1. The development of a classification system capable of being used to evaluate the "degree of hazard" of individual waste stream;

2. An inventory and characterization of the Special Waste streams in order to determine the availability of data on each individual waste stream, to develop criteria to guide the design of the proposed classification system and to prepare comprehensive listings of hazardous and non-hazardous Special Waste streams;

3. The identification of the 'state-of-the-art' disposal technologies applicable to Illinois' Special Waste streams; and

4. Test the proposed classification system by evaluating selected Special Waste streams.

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2.0 CHARACTERIZATION OF SPECIAL WASTE STREAMS

This chapter provides a description of the results of the study team's efforts to characterize Illinois Special Waste streams. As described earlier, the term "Special Waste" in Illinois refers to all industrial wastes, hazardous and non-hazardous. The term "waste stream" refers to a unique waste that results from a specific type of industrial process at a particular plant. For example, a metal finishing company may generate a specific kind of sludge consisting of liquids contaminated with various types of metals, depending on the specific metal finishing process being used. This specific waste product, a sludge is called a "waste stream". In order to develop a system by which these waste streams are categorized by their degree of hazard, it is first necessary to become familiar with, and analyze the waste streams themselves. The characterization of the waste streams involved several steps or processes, described as follows:

- Review and analyze Illinois EPA's records on Special Waste streams - permit and manifest files;
- Develop a comprehensive listing of unique (non-duplicative) waste streams;
- Identify important criteria (e.g., toxicity, flash point, acidity) for use in the proposed degree of hazard classification system;
- Determine volumes of waste streams; and,
- Develop criteria and select waste streams for testing the proposed Special Waste classification system.

2.1 Review and Analysis of IEPA Records

A system to categorize industrial wastes by degree of hazard requires a detailed and complete data base. Many experts have concluded that a degree of hazard system was not feasible simply because insufficient data

were available. In Illinois, the situation is different. It is widely recognized that Illinois has the most comprehensive data on both hazardous and non-hazardous industrial waste streams. In the following discussion, the IEPA data base is reviewed in order to provide an understanding of its strengths as well as its weaknesses.

2.1.1 Special Waste Disposal Permit Application

The waste disposal application master contains all of the information submitted jointly by the generator and disposer of a specific waste stream for which the permit is requested. This application is known as "Special Waste Disposal Permit Application." IEPA grants permission for the disposal of a hazardous or non-hazardous Special Waste stream, based on this application. This application provides detailed information to IEPA regarding the waste streams. Even though the same type of information is required for both hazardous and non-hazardous waste streams, more emphasis is placed on the accuracy and completeness of the information for hazardous wastes than for non-hazardous wastes.

Over the years, the format and specificity of data elements on the IEPA application have been changed several times. This situation has created difficulty in retrieving and interpreting the information. The Application Master Permit File has 30,539 records which represent the total number of hazardous and non- hazardous disposal permit applications made to date.

2.1.2 Special Waste Manifest History

The manifest history file contains complete information contained in the manifest documents. All Special Wastes disposed off-site, including both hazardous and non-hazardous wastes require a manifest. The manifest contains the identification number of the waste stream, the generator, the disposer, the site, as well as quantity information, the method of disposal, etc. There was a total of 122,012 records in this file.

2.1.3 Selected Inventory File

This file is basically an address file. It contains addresses, telephone numbers and contact names for each facility, including the sites generating industrial wastes, disposal sites, and treatment or storage sites. This file contains approximately 15,000 records.

2.2 Unique Waste Streams

Beginning with the 30,539 records from the Application Master Permit file, the study team was able to identify only 2,964 unique (non-duplicative) non-RCRA waste streams and 2,724 RCRA waste streams. These unique waste streams represent all the waste streams actually disposed of during calendar year 1983. Lists of non-hazardous and hazardous waste streams are contained in Appendices E and F respectively.

2.3 Identification of Available Data

The data for each of the unique waste streams include the following types of information:

1) Generic waste name and process or operation name;

2) Six principle components and their amounts expressed in percentages;

3) Waste class (RCRA - hazardous or non-hazardous), waste phase (solid, liquid or gaseous), volume units (cubic yards or gallons);

4) Toxicity, reactivity, corrosivity and fire hazard information; and

5) Details on the presence, quantities and leachability of selected hazardous compounds and metals.

Development of the proposed classification system was made possible by the existence of the detailed data base containing such information as listed above. However, it should be noted that numerous gaps and missing items were often found in the non-hazardous waste files. The reason for this may be due to the fact that the non-hazardous waste streams' regulations are somewhat less stringent.

2.4 Selecting Representative Waste Streams for Testing the System

Given the total number of unique non-hazardous waste streams (2,964), it was not feasible, within the context of this study, to apply the classification system to all of them. Consequently, it was necessary to select non-random samples of waste streams from the total universe of waste streams. The study team developed a series of criteria to guide the selection of waste streams to be analyzed with the proposed system. The selected waste streams included the following types:

- high volume waste streams
- high toxicity or hazard properties
- low or minimal toxicity or hazard
- waste streams frequently cited by industry and environmental groups

These criteria were utilized to ensure that the various types of industrial waste streams were tested by the proposed classification system. Appendix F depicts the list of waste streams selected for this testing. It was not possible to draw a statistically random sample; consequently, the conclusions regarding the total universe of waste streams were necessarily quite limited. However, there is sufficient diversity among the waste streams to provide a sense of how the classification works, that is, how it handles different waste streams.

One special subset of non-hazardous waste streams, six in number, were selected because they could be easily compared to their hazardous counterparts with similar physical and chemical properties. This special list was designed to facilitate a comparison between similar waste streams, some of which were regulated as hazardous under the Federal Resource Conservation and Recovery Act and some were not.

2.5 Determination of Waste Stream Volumes

Part of the characterization of waste stream data consisted of an analysis of data regarding the actual volumes of Special Waste disposed during calendar year 1983. Table 2-1 presents the total quantities of hazardous and non-hazardous wastes generated, treated, stored or disposed of in Illinois. A comparison was made of hazardous and non-hazardous waste streams of similar composition.

Figure 2-1 depicts the disposition of Special Waste streams disposed during 1983 which include the total non-hazardous and RCRA hazardous wastes disposed of off-site (away from the generator's property), the total RCRA hazardous wastes disposed of on-site (on the generator's property) and estimates for non-hazardous Special Wastes disposed of on-site. The total quantities of non-hazardous wastes do not need to be reported if disposed of on-site. However, by assuming the respective proportions of hazardous to non-hazardous wastes is the same for on-site disposal as it is for off-site disposal, then the estimated on-site quantities of non-hazardous wastes for 1983 would be approximately 568 million gallons and 10.3 million cubic yards.

SUMMARY OF HAZARDOUS AND NON-HAZARDOUS
SPECIAL WASTES MANIFESTED DURING 1983

TABLE 2-1

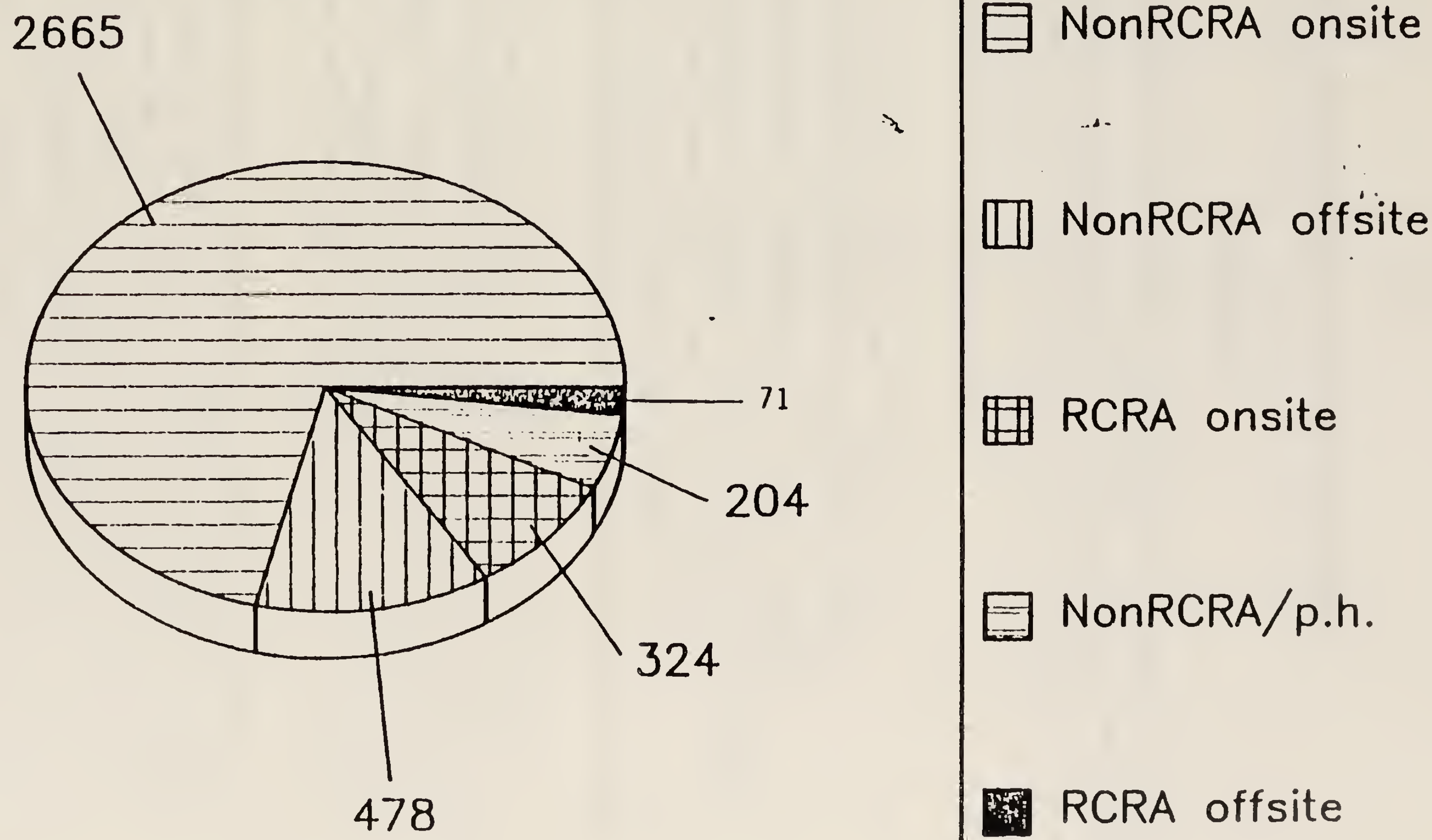
	Number of Waste Streams	Quantity	Unit
Non-hazardous Special Wastes[1] (Disposed off-site)	2,964	101,984,197	Gallons
		1,862,558	Cu. Yards
Hazardous (RCRA) Special Wastes[1] (Disposed off-site)	2,724	44,589,846	Gallons
		164,930	Tons
Hazardous (RCRA) Special Wastes[2] (Disposed off-site)	--	70,874,375	Gallons
Hazardous (RCRA) Special Wastes[2] (Disposed off-site)	--	323,827,853	Gallons
Non-Hazardous Wastes comparable to Hazardous Wastes[1]	162	11,147,695	Gallons
		99,604	Cu. Yards

Sources: 1. 1983 Manifest Files - Computed by DENR

2. Personal communication between K.R. Reddy and Greg Zak of IEPA on June 26, 1985.

Special Wastes in Illinois: 1983

(in millions of gallons of waste)



p.h. = potentially hazardous

FIGURE 2-1

3.0 REVIEW OF EXISTING CLASSIFICATION SYSTEMS

3.1 Overview

Several approaches are available for classifying industrial and commercial wastes according to degree of hazard. For the most part, the development of degree-of-hazard classification systems has been pioneered by state and federal regulatory agencies.

We considered several existing systems:

- State of Washington Waste Classification Scheme
- State of Rhode Island Waste Classification Scheme
- Michigan Rank-Order Assessment of Critical Materials
- JRB Environmental Containment Waste Characterization Scheme
- State of California Waste Classification Scheme
- State of Texas Waste Classification Scheme
- Chemical Manufacturers Association Waste Classification Scheme

as to their appropriateness for a classification system in the State of Illinois. Table 3-1 summarizes the types of data required for each of these classification systems. Toxicity, corrosivity and ignitability/flammability were considered for all schemes. Persistence and reactivity were considered in six of the systems while the other 13 characteristics were considered in even fewer systems.

When compared to the Illinois criteria advanced in Section 2, three systems emerged as being the most useful: Washington, Michigan, and JRB Systems. All three promised to provide a tool for classifying in terms of their range of information needs. They emphasized toxicity, and included chronic toxicity or carcinogenicity and other characteristics that Battelle deemed to be important. The systems were the only three that dealt with the quantity of the waste and thus promised to be able to utilize information about waste streams in the State of Illinois files.

In the State of Washington, a classification system has been implemented that categorizes wastes by degree of hazard. The Washington system is based in part on lists and also relies on scoring graphs for assigning degree of hazard. The State of Michigan has taken a different

TABLE 3-1. OVERVIEW OF TYPES OF DATA REQUIRED FOR VARIOUS DEGREE OF HAZARD WASTE CLASSIFICATION SCHEMES

Hazard Characteristic	Candidate Degree of Hazard Classification Schemes						
	Washington	Rhode Island	Michigan	JRB	California	Texas	CMA
Carcinogenicity	X	X	X		X		
Mutagenicity			X				
Teratogenicity			X				
Toxicity	X	X	X	X	X	X	X
Persistence	X	X	X	X	X		X
Bioaccumulation Potential			X		X		X
Solubility				X			
Irritation		X	X		X	X	
Infectiousness	X	X	X		X		X
Sensitization		X	X		X	X	
Radioactivity		X		X	X		X
Corrosivity	X	X	X	X	X	X	X
Reactivity	X	X	X	X	X		X
Ignitability/ Flammability	X	X	X	X	X	X	X
Explosiveness	X		X				
Volatility				X			
Physical State				X			
Waste Quantity	X	—	X	X	—	—	—
No. of characteristics	9	10	14	10	11	5	9

approach toward classifying special wastes. The Michigan system is based on individual numerical scores for various waste characteristics (e.g., carcinogenicity) that are summed or at least considered collectively before assigning a degree-of-hazard designation. JRB Associates has also developed a classification system for hazardous waste sites that has applicability to classifying special wastes. The JRB system is based on a scoring format like the Michigan system, but includes the additional component of weighting those waste characteristics that are deemed to be more important in assessing the overall hazard. Each of these systems is presented in more detail in the following section.

3.2 State of Washington Classification System for Dangerous Wastes

The state of Washington Degree of Hazard System consists of a screening process using lists as well as a more rigorous evaluation system for complex wastes. This approach is advantageous because many dangerous wastes can be easily identified and classified during the initial phase of the evaluation. In general, a waste is classified by degree of hazard by evaluating it against either (i) lists, (ii) characteristics, or (iii) criteria. The classification system results in one of three designations: dangerous waste, an extremely hazardous waste, or undesignated (Figure 3-1).

In the Washington system, the generator has two options for evaluating a waste. The purpose of the first option (i.e., the non-elaborate screening evaluation) is to ascertain whether or not the waste is designated by either the dangerous waste lists, dangerous waste mixtures regulations, or dangerous waste characteristics. In the second option, the generator determines whether or not his waste is designated by the dangerous waste criteria and characteristics (Figure 3-1).

In the first option, there are three lists which are used in the screening process. Two of the lists are essentially those that are found in the RCRA regulations (40 CFR 261). The first list is entitled discarded chemical products and contains the so-called "P" and "U" wastes in the RCRA regulations. The second list is called the dangerous waste sources list and

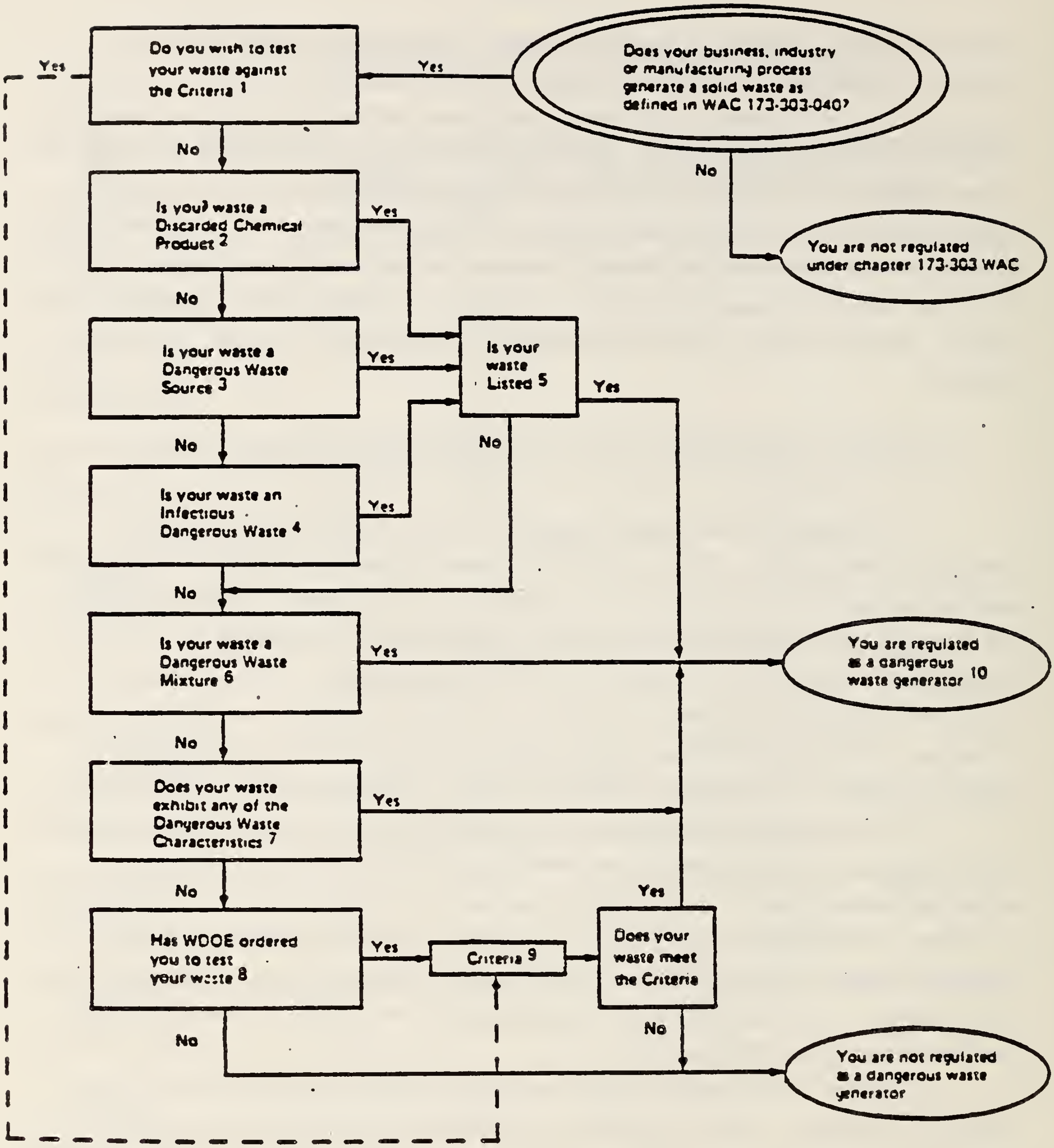


FIGURE 3-1. STATE OF WASHINGTON FLOWCHART FOR CLASSIFYING SPECIAL WASTE

Source: State of Washington's Dangerous Waste Regulations.

consists of the "F" and "K" waste sources in the RCRA regulations. The third list is the Infectious Dangerous Wastes List, although the state has not published the list pending U.S. EPA action (Potter, 1985).

One advantage of the Washington system is the simplicity of the system, since it is in part basd on lists. Using the lists, the generator determines whether his waste is a dangerous or extremely hazardous waste. In the fourth step of the first option, the generator determines whether a waste is to be considered a dangerous waste mixture, if it has not already been designated as dangerous or extremely hazardous by one of the lists.

In the Dangerous Waste Mixture evaluation the components of a waste are collectively evaluated for acute toxicity potential. The system has one important attribute in regard to toxicity, since components with high toxicity are given more weight in the analysis than low toxicity components. By taking into account equivalent concentration and volume, a generator determines the appropriate designation for a waste (see Figure A-1 and Table A-1, Appendix A). As the final step in the first option for classifying a waste, a generator must evaluate his waste against the dangerous waste characteristics, if the waste has not already been assigned a degree of hazard designation. These characteristics are the ones included in the RCRA regulations and include ignitability, reactivity, corrosivity, and EP toxicity.

One of the strengths of the Washington system is the inclusion of several important waste characteristics in the evaluation "criteria" which are incorporated into the second option of the system. For example, the Washington regulations outline methods for assessing the toxicity, persistence, and carcinogenicity of a waste mixture. Generators are to obtain all available information in order to ascertain these properties. The regulations indicate that the source of toxicity and carcinogenicity data may be the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) the EPA Spill Table, publications of the International Agency for Research on Cancer, or bioassays.

Persistent Wastes are defined as those that contain halogenated hydrocarbons or polycyclic aromatic hydrocarbons (PAHs) with more than three rings, but less than seven rings. The waste designation (i.e., Dangerous or Extremely Hazardous) is based on concentration and volume (see Figure A-2 and Table A-3, Appendix A). The system may be limited in its usefulness since

there are compounds that are persistent, but do not fall into this category of PAHs. Wastes that contain carcinogens (as defined by IARC) may be designated as Dangerous or Extremely Hazardous Wastes depending upon the quantity of the carcinogen.

Toxicity is handled in the second option of the Washington system in the same way that it is addressed in the first option. However, a generator may employ a bioassay (e.g., acute oral toxicity test) to determine the toxicity of a waste stream. In this case, the waste designation (dangerous or extremely hazardous is assigned according to the Toxic Category Table (Table A-1, Appendix A) and the Toxic Dangerous Waste Designation Table (Table A-2, Appendix A). For carcinogenicity determination, the regulations stipulate the use of IARC plus rules for determining designation via concentration of carcinogens and the monthly or batch quantity. In short, many attributes of the Washington system are consistent with the criteria originally proposed for guiding the development of the Illinois system.

3.3 State of Michigan's Critical Material Register

Since the State of Washington's approach to degree-of-hazard classification is just one of a number of such systems, it was necessary to review other methods that try to accomplish the same thing. The State of Michigan's Critical Material Register (CMR) attempts to evaluate a waste's degree of hazard by scoring it against certain of its component properties.

The register consists of a list of chemicals which are or may be used and/or discharged in the state. It is an actual list of inorganic and organic materials, pesticides, drugs, food additives, and natural materials. The chemicals are evaluated under a defined criterion to determine if they should be included on the list. The procedure was implemented in 1978, replacing the previously used model for screening and selecting critical materials (Figure A-3, Appendix A). The review process utilizes a hazard assessment methodology which considers acute toxicity, carcinogenicity, mutagenicity, teratogenicity, persistence, bioaccumulation, and other adverse effects (including subacute and chronic toxicity, embryotoxicity, phytotoxicity, and aesthetics). A waste is numerically scored in each of the

seven categories. The factors wnich have the highest potential for the most severe adverse impacts on the environment and human health, i.e., acute toxicity, carcinogenicity, mutagenicity, teratogenicity, bioaccumulation, and low dose effect, may receive a maximum score of 7. The other factors of less concern have a lower maximum score.

Classification into the various scoring levels in all of the factors is based on generally accepted terminology and the available literature. The hazard assessment criteria used by Michigan is listed in Tables A-4 to A-10 in Appendix A. However, one disadvantage of the Michigan system is to reliance upon extensive information bases and highly technical judgment skills to assign scores for some of the waste characteristics (e.g., carcinogenicity).

The chemicals receiving a high score, i.e., seven in one factor or a cumulative score of seven, are included on the register. The chemicals receiving a score of less than seven total points are not considered "critical materials". In categories where insufficient data are available, an asterisk is assigned instead of points. The total number of asterisks received are recorded. Those chemicals with a high number of asterisks are placed high on the list of chemicals for review, called the "List of Priority Chemical Substances for Further Evaluation".

One favorable attribute of the Critical Materials Register is that it is updated every year. Chemicals appearing on the CMR, and chemicals found in reviews to have a potential for adverse effects on human health or the environment, or are produced in large quantities, are the first of approximately 200 to be reviewed each year. The list can also be changed because of formal appeals filed by industry. If the review by the Critical Material Advisory Committee determines the appeal valid, the chemical is removed from the list. When a new chemical is added to the list, there is a one year grace period before certain information on these chemicals is reported.

Every business using and discharging a listed "critical material" must file an annual report including information on type, source, quantity, disposal method, location, and storage procedure. The Department of Natural Resources staff evaluates each site on the reported data, characteristics of the facility, quantity, and properties of the critical material itself, to

determine if there is potential harm. Also, all businesses storing or using a chemical on the CMR must develop a Pollution Incident Prevention Plan. The plan must include (1) procedures for preventing pollution, (2) emergency clean-up procedures, (3) types of surveillance employed to detect possible pollution, and (4) methods of keeping inventories.

3.4 JRB Rating System for Risk Potential

JRB Associates (1982) have developed a system in which land disposal facilities containing hazardous wastes can be evaluated. The methodology is designed primarily for landfills, surface impoundments, and other types of land-based storage and disposal facilities. Incinerators and waste treatment facilities cannot be evaluated by this scheme, with the exception of the solid wastes produced by them. The system is a site based evaluation and is not designed to be a waste categorization process. However, it contains procedures that may be adaptable to hazardous waste categorization and, therefore, is included in this review of classification systems.

The system consists of 31 rating factors that are divided into 4 categories: receptors, pathways, waste characteristics, and waste management practices. Each of the 31 factors has a 4-point scoring scale associated with it. The factor-specific scoring levels range from 0, meaning no potential hazard, to 3, meaning high potential hazard. All of the factors are not considered to be of equal importance; therefore, each has been assigned a weighting factor, called a multiplier. The sum of products for the 31 factors divided by the maximum possible score times 100 is the site's rating. The ratings range from 0 to 100 (100 being most hazardous). Ratings for each of the 4 categories can also be calculated for a site in the same way. Additional points can be assigned outside these categories if all problems are not included in the rating factors. Missing or unknown data are handled by calculating the percentage of missing or assumed values.

The system is primarily one of ranking or comparing various sites to each other, or to standards based on sites nationwide. They can be ranked by overall score, subscores of the 4 categories, combination of scores, and percentages of missing data. The rankings can then be used to determine the sites requiring collection of additional background information, site investigation, preparation of enforcement cases, and evaluation of potential hazard.

The category of waste characteristics may have elements adaptable for categorizing hazardous wastes. Waste characteristics refer to the type of hazards posed by materials in the facilities in terms of potential to cause harm to human health or the environment. This may be helpful in identifying hazardous or potentially hazardous chemicals.

The wastes are evaluated on nine characteristics: toxicity, radioactivity, persistence, ignitability, reactivity, corrosiveness, solubility, volatility, and physical state (Table A-11, Appendix A). Information sources are provided for each of the rating factors (Table A-12, Appendix A). Toxicity measures the potential for adverse health effects, including both chronic and acute. Waste characteristics not included in this evaluation system, but suggested by JRB for additional point consideration, are carcinogenicity, teratogenicity, mutagenicity, high-level radioactivity, high bioaccumulation potential, and infectivity.

3.5 Options for Illinois System

The comparative review of these classification systems revealed that there are existing classification systems whose purposes and information requirements vary. One option for the Illinois system was to utilize either the Washington, Michigan or JRB system as it currently exists. Another option was to modify one or more of these systems, and the third option was to develop a completely new system.

Many discussions explored the pros and cons of each option. Using an existing system would reduce costs but would not meet all of Illinois' criteria. Building a new system would be more costly in terms of time and money, but could better address Illinois total needs. Eventually, it was decided to take advantage of the best of the three existing schemes to modify and extend their work. As such, we relied most heavily on the State of Washington for dangerous waste regulations. Although the system developed for Illinois drew from this and the other systems, many major modifications of the systems and totally new concepts were developed. For example, none of the systems adequately considered disposal and treatment approaches by attempting to integrate waste disposal with degree of hazard. Table 3-2 presents a comparison of the proposed Illinois and Washington systems.

TABLE 3-2. COMPARISON OF WASHINGTON AND ILLINOIS CLASSIFICATION SYSTEMS

	Washington	Illinois
Approach	Screen and more rigorous evaluation for complex wastes	Screen and detailed Degree of Evaluation
Characteristics	Carcinogenicity Acute Toxicity Aquatic Toxicity Persistence Infectiousness Corrosivity Reactivity Ignitability/Flammability Explosiveness Waste Quantity	Carcinogenicity Mutagenicity Acute Toxicity Aquatic Toxicity Persistence Infectiousness Ingitability/Flammability Leachability Bioaccumulation Solubility Biological Characteristics Waste Quantity
Outcome	Waste Stream assigned hazard category of dangerous waste, extremely hazardous, or undesignated	Waste stream assigned to category (e.g., high moderate, low, or negigible) for five hazard characteristics: toxicity, fire, disease, biological, or leaching agent. Characteristics matched to disposal options.
System considers volume and concentration	Yes	Yes
System Considers complex mixtures	Yes	Yes
Evaluation criteria	Lists, definitions and standards	Lists, definitions, and standards
Role of State government waste generators	Reviews appeals from waste generators	Reviews conclusions of waste generator in Screen and Degree of Hazard Evaluation

4.0 PROPOSED ILLINOIS SPECIAL WASTE CLASSIFICATION SYSTEM

The State of Illinois has thousands of industrial waste streams or special wastes. In order to protect the environment and public health these waste streams need to be better classified according to their degree of hazard. It has been recognized that classification systems are a feasible approach toward better management of wastes that are dangerous to health or the environment. In turn, the results of a classification system can also guide the disposal of each waste stream.

The purpose of the proposed waste classification system is to categorize waste streams currently referred to as "special wastes" according to the degree of potential or actual risk that is posed to human health and the environment.

The study team identified several general criteria which would guide the development of this system which are as follows:

- The system must be simple, yet comprehensive enough so that it can be defended on sound scientific principles.

- Comprehensive in terms of waste characteristics considered

- Emphasis on toxicity

- Reliance to the maximum possible extent on use of waste stream information in files of the State of Illinois as well as other sources.

- Capable of making distinctions or discriminations among waste streams to assure possible matches to disposal

- Emphasis on output that does not integrate all waste characteristics into a single number or score, rather several outputs that facilitate the identification of alternative disposal options.

- Consisting of interrelated parts which are designed to conduct the analysis at different levels of complexity.

The criteria were used throughout the project to guide the development of the proposed Illinois Special Waste Classification System.

4.1 OVERVIEW OF SYSTEM

The waste evaluation and classification system is based on a two-phase approach. The two phases are presented in Figure 4-1 and consist of the Special Waste Screen and the Degree of Hazard Evaluation. A third aspect of the classification system is the treatment/disposal evaluation which is also depicted in Figure 4-1.

The outcome of the proposed classification system is an assessment of the degree of hazard posed by a special waste for five possible waste characteristics: toxicity, disease, fire, leaching agents and biological. After a special waste has been evaluated for each of these five waste characteristics then the waste may be considered in the treatment/disposal evaluation.

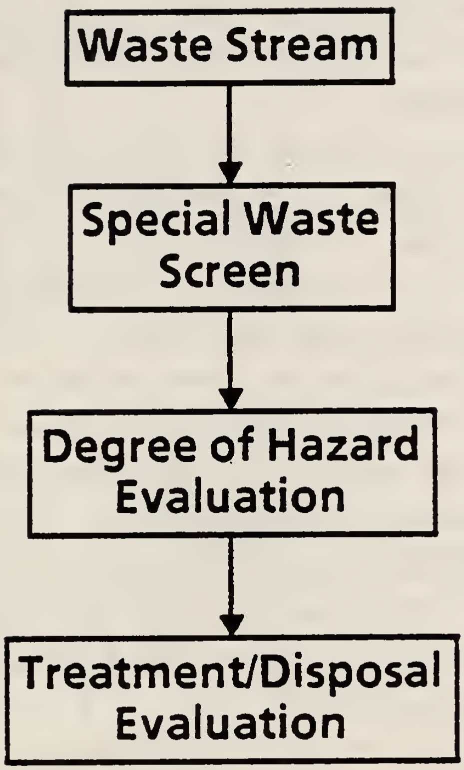


FIGURE 4-1 OVERVIEW OF THE WASTE CLASSIFICATION SYSTEM

4.1.1 Special Waste Screening Evaluation

The first phase of the proposed system is the Special Waste Screen. This screen is designed to rapidly determine whether a waste is subject to the Special Waste classification. This screen consists of 10 steps and is accomplished by comparing chemical substances in the waste stream to a series of lists, standards, or definitions.

For any waste that is evaluated by the Special Waste Screen, there are three possible outcomes of the evaluation process. Some wastes may pass completely through the screen and will not be subject to the Degree of Hazard Evaluation. Other wastes will be classified as RCRA wastes, and are therefore subject to the Illinois hazardous waste regulations. A third outcome is a requirement that the waste proceed to the Degree of Hazard Evaluation. A flow diagram of the Special Waste Screen is presented in Figure 4-2.

The first step in the screen is to determine whether the waste is a "listed" or characteristic waste as defined by RCRA. If the waste stream is determined to be a RCRA hazardous waste, it is regulated by the Illinois RCRA management program. However, the proposed system is designed so that a RCRA waste could be evaluated for degree of hazard and subsequently assessed for an appropriate disposal or treatment method.

If the waste stream is not a RCRA hazardous waste, then it proceeds to the toxicity part of the screen where it is evaluated for chronic, acute, and environmental (aquatic) toxicity. The evaluation criteria used for this screening are the most conservative levels of toxicity taken from the Degree of Hazard Evaluation. This approach ensures that wastes exhibiting any significant degree of toxicity are more rigorously examined. If any component of any waste stream is found to exhibit the minimum degree of toxicity or if toxicity data are not available for any component of the waste stream, then that waste stream proceeds to the Degree of Hazard Evaluation. The order of the characteristics covered in the screening evaluation has been considered. Toxicity characteristics are evaluated first, since they are of primary importance. Characteristics related to environmental fate (i.e., persistence, bioaccumulation, and solubility) are not included in the screen, since these factors are secondary characteristics that modify toxicity. For example, a waste that is persistent or soluble has little environmental or public health signficance if the waste is relatively non-toxic.

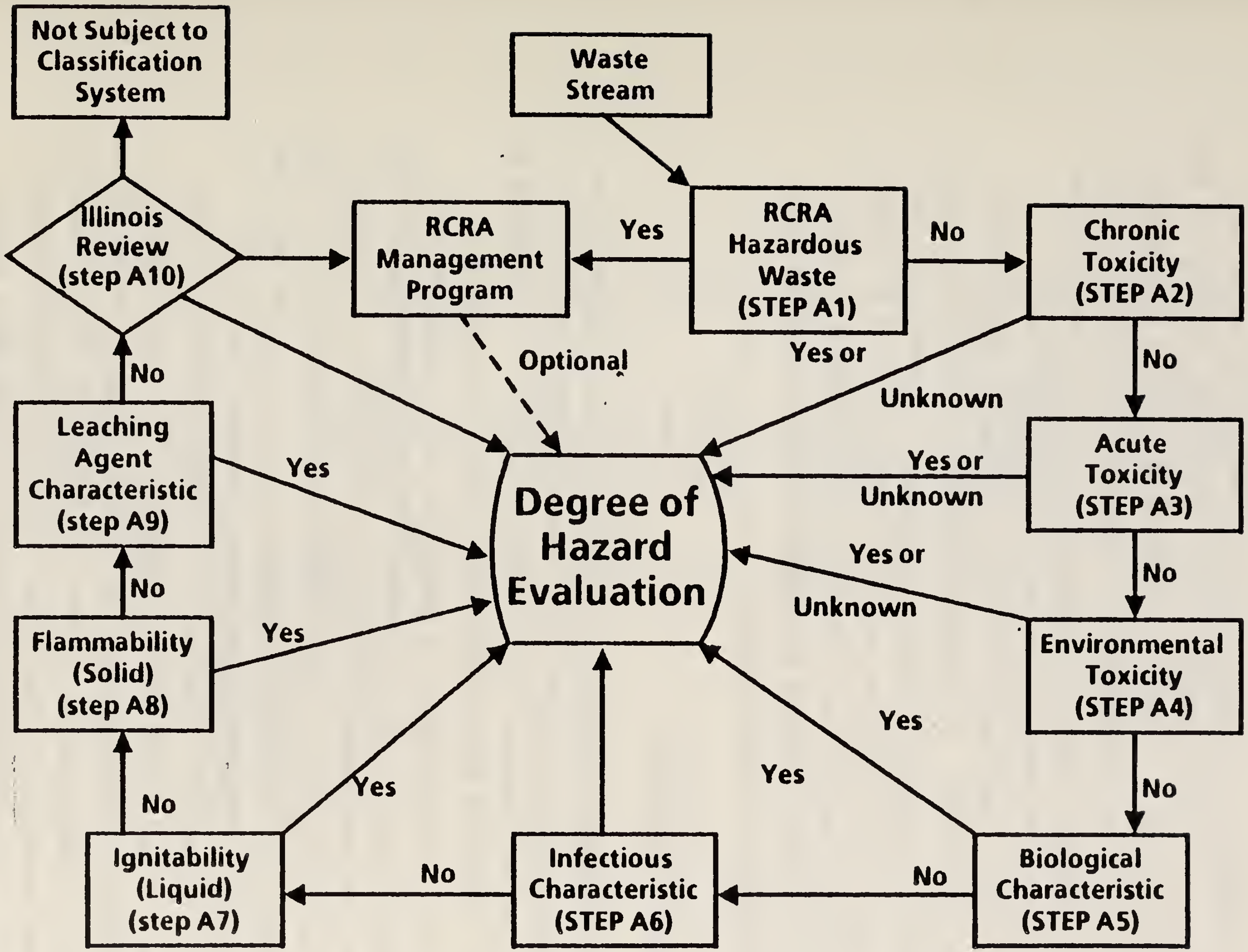


FIGURE 4-2 SPECIAL WASTE SCREEN (STEP A)

When all components of a waste stream are found to be below the threshold for toxicity, the waste stream proceeds through the remainder of the screen. For example, a waste is evaluated to determine if it is a biological or infectious waste, if it is an ignitable or flammable waste, and finally if it has the capacity to cause leaching of other materials (if it were disposed in a landfill). If the waste does not meet any of the definitions of the remaining characteristics, then the waste may be subject to a more thorough review by the State of Illinois. A detailed review may indicate that a waste should be considered in the Degree of Hazard Evaluation. Another possible outcome of the review is that the State may decide that the waste is indeed a RCRA hazardous waste and place the waste into the RCRA management program. The state reviewers may agree with the assessment and decide that the waste should not be considered as a special waste.

4.1.2 Degree of Hazard Evaluation

The second phase of the Special Waste Classification System is the Degree of Hazard Evaluation (see Figure 4-3). This evaluation is a detailed review of toxicity and environmental fate characteristics of all components of each waste stream. The first step of this phase is the Toxicity Hazard Evaluation (Fig. 4-4). This procedure is described in 4.3.1 (Step B) and scores the accumulative toxicity of all components in the waste streams based on their volume and weighted concentrations. Each waste stream is assigned a numerical score, and if the score is the highest score possible (i.e., 3), the waste proceeds directly to the Degree of Toxicity Hazard Evaluation step (Section 4.3.1.3 - Step B3). A waste with the lowest score on accumulative toxicity (i.e., 0) also proceeds directly to the Degree of Toxicity Hazard Evaluation. It was concluded that when a waste scores the highest level on toxicity that it should be categorized as the highest degree of hazard regardless of persistence, bioaccumulation, or mobility potential. The project team also concluded that environmental fate characteristics were not significant if the waste possessed low toxicity (i.e., a score of 0). Only those wastes receiving a score of 1 or 2 on accumulative toxicity are evaluated for environmental fate characteristics.

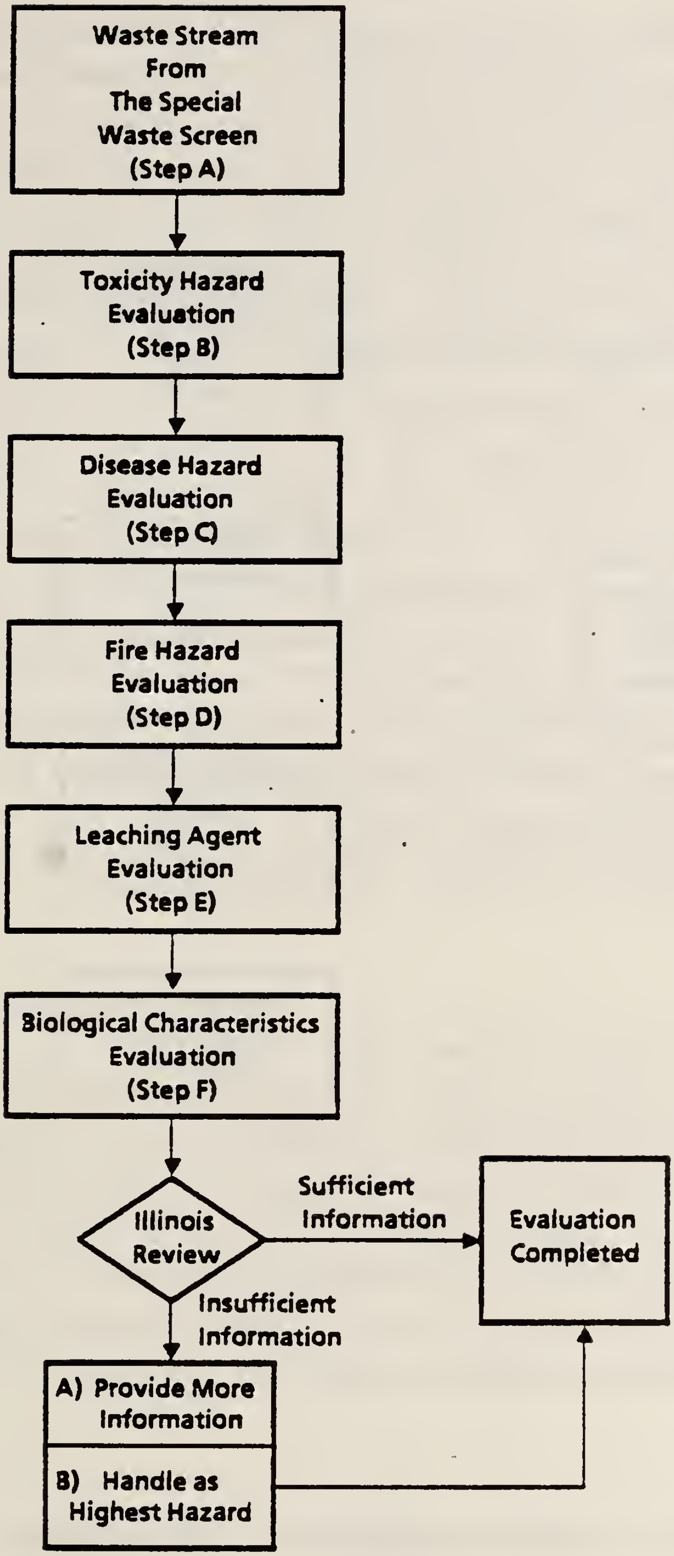


FIGURE 4-3. DEGREE OF HAZARD EVALUATION

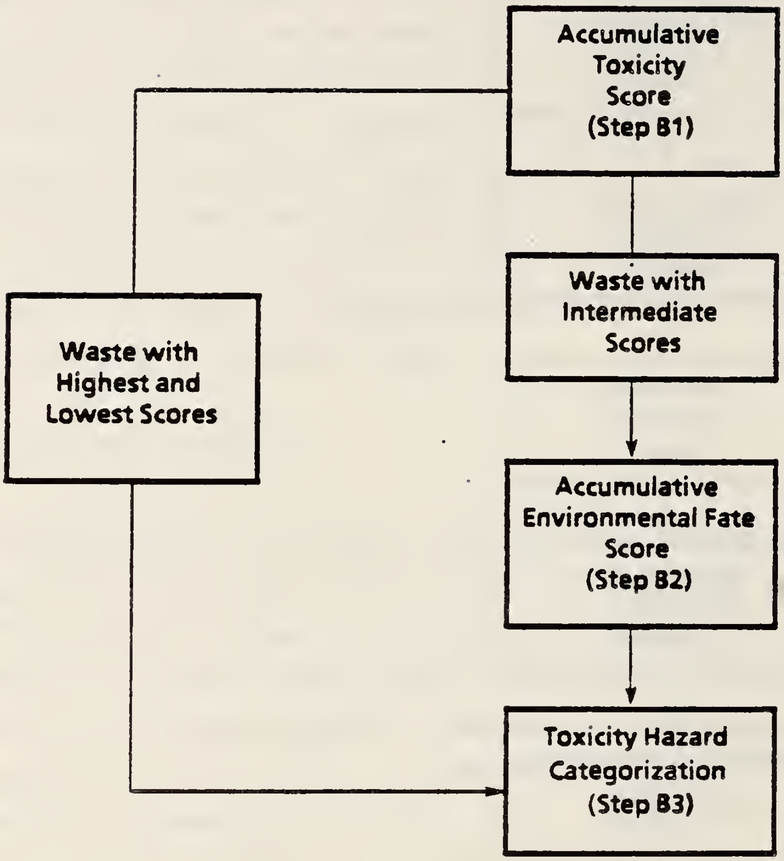


FIGURE 4-4. TOXICITY HAZARD EVALUATION (STEP B)

The environmental fate characteristics that are included in this evaluation phase are bioaccumulation potential, environmental persistence, and solubility. This evaluation process is similar to the one developed for toxicity in that a numerical score is derived for a waste stream. Using a decision tree approach the environmental fate score is then combined with the accumulative toxicity score, and the waste is assigned to an overall toxicity hazard category (Section 4.3.1.3 - Step B3). The Degree Toxicity Hazard Evaluation is one step of five that are carried out for each special waste. Hazard categories are also determined for characteristics, such as disease (infectious) potential, fire (ignitability and flammability), leaching agent potential and biological characteristics. The final step in the proposed system includes a review by the State of Illinois. When the state determines that sufficient information has been utilized and the categories have been arrived at appropriately, the waste is then evaluated for disposal or treatment. In the proposed system if the State reviewing agency determines that insufficient information has been used for the degree of hazard characteristic evaluation, then more information may be required through a more extensive literature review or actual testing, or it may be appropriate to assign the waste to the highest hazard category for any characteristics that can not be fully evaluated.

4.1.3 Disposal/Treatment Evaluation

The disposal/treatment evaluation, which is a guide in selecting the waste disposal method, is the third aspect in the overall evaluation of waste stream. The disposal/treatment evaluation is based on results of the five hazard evaluations performed in the Degree of Hazard Phase. The disposal/treatment evaluation is presented in greater detail in Section 6. If a waste stream passes through the Special Waste Screen and is not subject to the special waste classification system, the disposal/treatment evaluation is not required.

4.2 Step A: Special Waste Screen

The purpose of the Special Waste Screen is to rapidly and as simply as possible evaluate a waste stream to determine whether it is subject to the Degree of Hazard Evaluation. The various steps in the screen can be generally regarded as specific questions that can be answered with a yes or no. Those questions where the answer is unknown are handled in the same manner as a positive response and proceed to the detailed evaluations. The screen is designed to provide a conservative level of protection of the environment.

4.2.1 Step A1 -- RCRA Hazardous Waste Determination

Decision Criteria. The first step in the Special Waste Screening evaluation is to determine whether the waste meets the definition of a hazardous waste as defined by the federal Resource Conservation and Recovery Act regulations (40 CFR 261). If the special waste meets the definition of a RCRA hazardous waste, then there are other regulations enforced by the State of Illinois which govern that wastes' handling and disposal. If the waste does not meet the RCRA definition, then it proceeds to the next step of the screening evaluation.

Rationale. The Illinois Special Waste Classification System is designed to distinguish wastes with different degrees of hazard and to identify the appropriate treatment/disposal methods for these wastes. This system is not intended to replace the Illinois RCRA management program, however, this classification system has the capacity to assess the degree of hazard of RCRA wastes and to recognize appropriate treatment and disposal methods.

4.2.2 Step A2 -- Chronic Toxicity

Decision Criteria. Chronic toxicity is defined in this system as the capacity for a special waste or component of the waste to elicit a carcinogenic or mutagenic effect in animals or humans. In this step, a waste or

any of its components is assessed for chronic toxicity potential by determining if a chemical substance in the waste appears on a current list of carcinogens published annually by the National Toxicology Program (NTP). The most current list appears in Table B-1, Appendix B. Mutagenicity status is determined by a positive test for mutagenesis in any of the tests provided below and reported in any of the NTP annual summaries; Salmonella assays, cytogenetic effect in Chinese hamster ovary cells, mouse lymphoma cells, and heritable genetic effects in Drosophila.

Rationale. The characteristics of carcinogenic and mutagenic substances are important considerations because of the adverse impacts these substances may have on health or the environment. Each year the NTP publishes a report containing a list of all substances which are either known to be carcinogens or may be reasonably anticipated to be carcinogens. Known carcinogens are defined by NTP as "those substances for which the evidence from human studies indicates that there is a causal relationship between exposure to the substance and human cancer" and reasonably anticipated carcinogens are defined as "those for which there is limited evidence of carcinogenicity in humans or sufficient evidence of carcinogenicity in experimental animals". The NTP reviews are comprehensive evaluations of carcinogenicity, since they are based on the toxicology activities of the National Institute of Environmental Health Sciences (NIEHS), the Food and Drug Administration (FDA), the National Institute for Occupational Safety and Health (NIOSH), and the National Cancer Institute (NCI).

One significant advantage of the use of a list in the Special Waste Screen is that its use requires no additional research. The only determination is whether any component of a waste stream appears on the list. The list is updated annually and is compiled with the most recent data available from agencies conducting carcinogenicity assays.

The results of mutagenicity assays are also reported annually by NTP (1979 through 1984). However, it is recognized that the results of mutagenicity tests are not as clear cut as those for potential carcinogens. At this time, no single, defensible list of known or anticipated mutagens exists. Mutagenetic testing is primarily used as a screening procedure for carcinogens. The NTP annual summaries for the past six years are currently

the most reliable source of information in this area. The results are current, since they are based on yearly reports and contributions for numerous testing agencies. Current findings of NIEHS, NCTR, and NIOSH are reported in annual reports. Results are recorded as positive, negative, weak response, and equivocal. Numerous mutagenicity test results are reported, including Salmonella assays, cytogenetic effects in Chinese hamster ovary cells, mouse lymphoma cells, and heritable genetic effects in Drosophila. In the Special Waste Screen, if a chemical receives one positive or weakly positive result in any of the tests reported by NTP, it would fall into the degree of hazard evaluation. Potential, but yet unproven, adverse health effects are given consideration using this conservative criteria.

Teratogenicity and other reproductive effects are another category that were given consideration for inclusion in the special waste screening evaluation. Data on the teratogenic effects of various chemicals may be found in reports and texts by Rao et al.(1982), Fraumeni(1974), Shepard(1980), Wilson and Fraser(1977), and Mattison(1983). The reference by Shepard(1980) is probably the most comprehensive on the subject. However, there is no source of data which is updated periodically or provides conclusive evidence of the teratogenic potential of a chemical in humans. At this time, there are insufficient data to include teratogenesis in the screening procedure. The U.S. EPA is currently working on guidelines for assessing developmental toxins (Federal Register, Vol. 49, No. 227, Nov. 23, 1984, 46324-46330).

4.2.3 Step A3 -- Acute Toxicity

Decision Criteria. In this step, a waste or components of a waste are evaluated for oral, inhalation, and dermal toxicity in mammals. If the waste stream exceeds the proposed criterion in any of the following three categories, it is required to be evaluated further in the degree of hazard evaluation:

Oral LD_{50} (rat) (mg/kg)	Inhalation LC_{50} (rat) (mg/l)	Dermal LD_{50} (rabbit) (mg/kg)
$\leq$ 5000	$\leq$ 200	$\leq$ 20,000

Acute toxicity values are available in numerous sources. If a waste stream or any of its components have not been assayed for acute oral, inhalation and dermal toxicity then the waste is required to be evaluated in the Degree of Hazard Evaluation. Waste streams that are determined not to pose an acute toxicity hazard are reviewed in the next step of the Special Waste Screen (i.e., biological waste).

Rationale. Acute toxicity is an important factor for consideration in analyzing the potential hazards of a special waste. While a chemical may not have chronic effects (i.e., cause cancer), it may cause other adverse effects on man or the environment.

The States of Michigan and Washington have established LD_{50} and LC_{50} criterion for designating a substance as acutely toxic. The systems in these states indicate that these criteria are effective in identifying toxic chemicals. In both systems a chemical is evaluated for oral and dermal toxicity. The criteria proposed for use in an Illinois system are adapted from the Washington regulations using a conservatively low toxicity value to catch even a slight toxic effect. These criteria are based on generally accepted values found in the literature on acute toxicity (Hodge and Sterner, 1949; Gleason et al., 1977; National Academy of Science, and U.S. EPA, 1975, as cited by the Michigan Critical Materials Register).

Acute oral, inhalation, and dermal LD_{50} and LC_{50} values for rats and rabbits are easily attained from a variety of sources. These data may be found in the EPA Spill Table, in the Code of Federal Regulations, and the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS). RTECS compiles data through extensive literature searches and is available on-line or published on microfiche quarterly. Both RTECS and the Spill Table are readily available and simple to use.

4.2.4 Step A4 -- Environmental Toxicity

Decision Criteria. If a waste has not been referred to the Degree of Hazard Evaluation in the first three steps of the special waste screen, then it is evaluated for potential environmental toxicity. The form of

toxicity in this step is aquatic toxicity. The criteria used are the LC_{50} values obtained over 48-hour or 96-hour exposure periods. The environmental toxicity criteria is an LC_{50} (fish) value $\leq$1000 mg/liter.

Rationale. Environmental toxicity studies may be grouped by the types of organisms that are evaluated, but usually fall into one of two categories: terrestrial or aquatic. There is a paucity of terrestrial toxicity data and therefore inclusion of this characteristic in the special waste screen is impractical. However, aquatic toxicity data are readily available for many chemicals. One of the sources of aquatic toxicity data, including data on inorganic compounds, is the Ambient Water Quality Criteria Documents published by the U.S. EPA. The environmental/aquatic toxicity criteria proposed for use in the Illinois system are the same as those used by the State of Washington, where a LC_{50} (fish) value of less than 1000 mg/liter is currently being used. This value is a conservative criterion designed to identify substances posing a potential hazard to aquatic organisms.

4.2.5 Step A5 -- Biological Characteristics

Decision Criteria. A waste stream is considered to have adverse biological characteristics when it is a liquid, solid, semisolid or gaseous waste generated by humans, animals or plants as a direct or indirect result of the manufacture of a product or the performance of a service and could result in:

1) generation of a leachate that has a high biological oxygen demand,

2) generation of gases such as methane or hydrogen sulfide,

3) attraction of vector type organism such as rats, flies and other vermin or

4) generation of offensive odors.

Biological waste, includes but is not limited to, biological pond sludge, animal rendering waste, vegetable by-products, meat packing waste, food processing waste and hydrolyzed vegetable protein.

Rationale. Biological wastes may not be infectious but may still present a real or potential threat to human health or the environment. They also possess properties which make disposal in a landfill difficult to manage by normal means. Therefore, this evaluation is an important and needed step in the Special Waste Screening procedure.

4.2.6 Step A6 -- Infectious Characteristics

Decision Criteria. Infectious waste is identified through a definition in the same way as a biological waste. If the waste stream meets the definition of an infectious waste (Title 35, Subtitle G, Chapter I, 809.901) then it proceeds to the Degree of Hazard Evaluation. Table B-3 in Appendix B provides the Illinois definition of an infectious waste.

Rationale. Infectious waste is included in the Special Waste Screening procedure, because of its potential for disease transmission to waste handlers and the general population. The Illinois definition of an infectious waste covers most waste streams that could be contaminated by an infectious agent derived from human sources. One weakness of the definition relates to the fact that it does not include waste stream originating from other sources, such as veterinary wastes, that could be contaminated with zoonotic agents that are also capable of causing human illnesses depending upon the circumstances of exposure.

4.2.7 Step A7 -- Ignitable Liquid Characteristics

Decision Criteria. A special waste exhibits the characteristic of ignitability if a representative sample of the waste is a liquid that has a flashpoint at or above 140F (60C) and below 200F (93.3C) as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D-39-79 or D-93-80.

Rationale. The 140F lower range limit will identify those ignitable wastes not regulated by RCRA. The 200F range ceiling corresponds with the upper limit for ignitable liquids set by the U.S. Department of Transportation. The 200F upper limit is not meant to imply that any liquid having a flashpoint above 200F is nonflammable or noncombustible.

4.2.8 Step A8 -- Flammable Solid Characteristics

Decision Criteria. A special waste is considered flammable if it exhibits the characteristics outlined by the U.S. Department of Transportation (DOT) for flammable solids.

According to the DOT, a "flammable solid" is any solid material, including gels and pastes, other than one classed as an explosive or a blasting agent, which is described as one of the following:

(a) Pyrophoric solids which ignite when exposed to moist air at or below 55C (130F), or

(b) solids subject to spontaneous heating by reaction with oxygen and which contain unsaturated oils or other easily oxidizable substances, or

(c) solids subject to spontaneous heating by fermentation or bacterial action and which self-heat due to the action of bacteria or other organisms, or

(d) readily ignitable solids which are easily ignited and burn so vigorously and persistently as to create a hazard in transportation, or

(e) solids which can be ignited by friction, or

(f) solids which in contact with water evolve flammable gases, or

(g) solids or molten materials shipped at (elevated) temperatures exceeding 315C (600F), which can cause ignition of combustible materials.

Tests used to evaluate the above descriptions are described in the Federal Register, 1981, May 7, Vol. 46, No. 88, p. 25493 (Figure B-2, Appendix B).

Rationale. The definition of flammability refers to solids which are not otherwise considered in the RCRA regulations on ignitability. This step insures a greater degree of protection for those persons who are handling and disposing of the waste as well as for the public and the environment.

4.2.9 Step A9--Leaching Agent Characteristics

Decision Criteria. A waste is considered to have leaching characteristics if its pH is less than 4 (very acidic) or greater than 10 (very alkaline).

Rationale. Leaching is an environmental concern because as leached substances move from a land disposal site through the ground it is possible that they may eventually reach and contaminate the surface or ground water. Federal regulations under RCRA define corrosive hazardous waste as having a pH less than 2 or greater than 12.5. Wastes which have a pH less than 4 or greater than 10 must still be considered to be a potential hazard because of the very acidic or very alkaline environment that they could create which could lend itself to the leaching of other hazardous materials (e.g., heavy metals).

4.2.10 Step A10--State of Illinois Review

Should a waste pass through the entire screen without a positive response to any screening questions, it must then be reviewed by the State of Illinois for concurrence. The State may choose to require a degree of hazard evaluation or they may concur that the waste stream is not a special waste. They may also conclude that the waste is actually a RCRA hazardous waste and refer the waste to the Illinois hazardous waste management program.

4.3 Degree of Hazard Evaluation

The Degree of Hazard Evaluation is required of all waste streams that meet any of the decision criteria in the special waste screen. This phase of the classification system consists of five hazard characteristics

that are addressed in the following order: toxicity hazard, disease hazard, fire hazard, leaching agent hazard and biological characteristics hazard. The degree toxicity hazard evaluation may be broken further into three steps: the accumulative toxicity evaluation, the environmental fate evaluation, and the toxicity hazard categorization step. Both of the toxicity and environmental fate evaluation components involve several steps which result in assigning a score ranging from 0 to 3 for use in the toxicity hazard categorization step. In the Degree of Hazard Evaluation volume and concentration of chemical components as well as mixtures are taken into account. Due to the nature of the information that is required for this phase of the classification system, an evaluation form is used to assist at the various decision points.

4.3.1 Step B -- Toxicity Hazard Evaluation

As indicated previously, the toxicity hazard evaluation step takes into account the toxicological and environmental fate properties of a special waste. The study team concluded that environmental fate properties such as bioaccumulation, persistence, and solubility are important characteristics to consider after an assessment of a waste's toxicity has been made. Step B of the Degree of Hazard Evaluation consists of many steps which are designed to derive an overall toxicity hazard category (Fig. 4-4). The first step in this process is to determine the accumulative toxicity of all components of special waste stream.

4.3.1.1 Step B1 -- Accumulative Toxicity Scoring. The first step in determining toxicity hazard is scoring the accumulative toxicity. There are three steps to this process (Fig. 4-5). The first is assigning a weighted toxicity category for each component of the waste stream by using the toxicity weighting table. The second part is applying the weighted categories to the equivalent concentration formula. The sum arrived at using this formula is then applied to the accumulative toxicity scoring graph where an accumulative toxicity score is acquired.

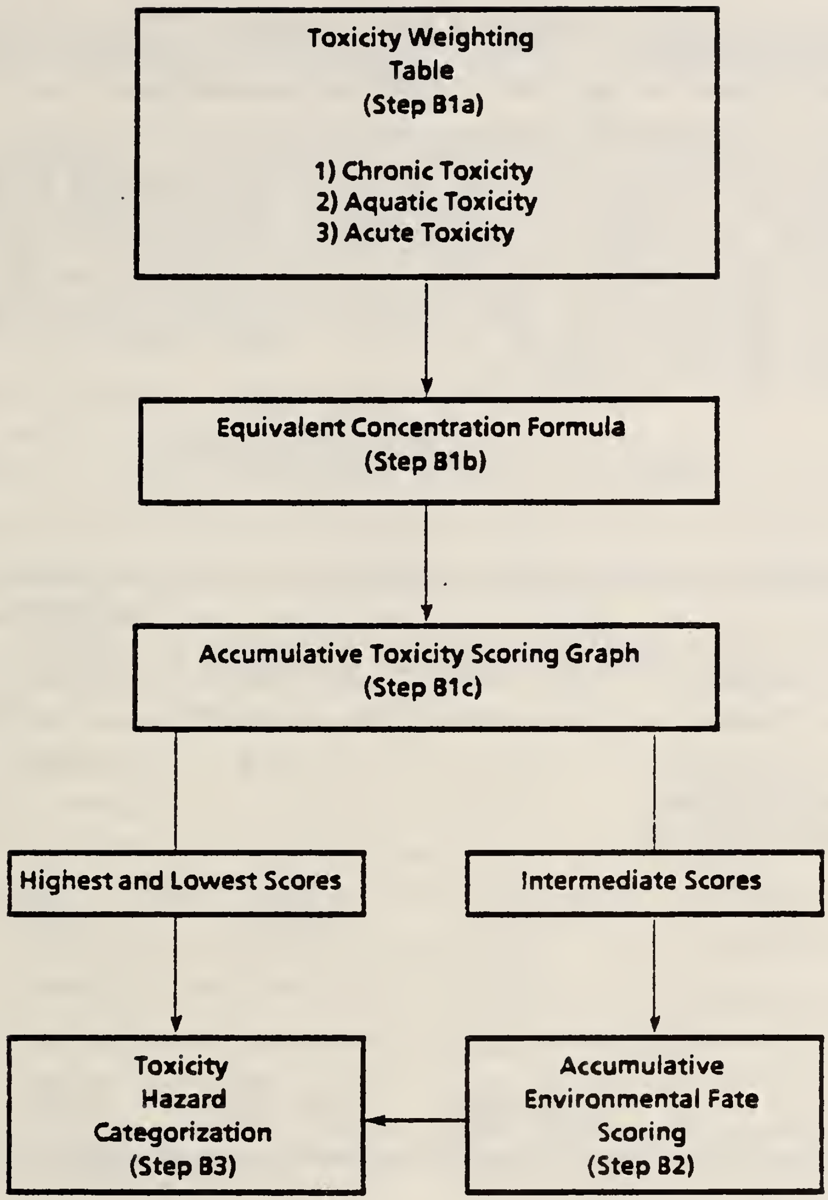


FIGURE 4-5. ACCUMULATIVE TOXICITY SCORE (STEP B1)

4.3.1.1.1 Step B1a -- Toxicity Weighting Table.

Decision Criteria. Accumulative toxicity is evaluated using the toxicity criteria found in Table 4-1. This table establishes five levels of toxicity, each level differing from the preceding level by a factor of 10. Chronic toxicity is weighted at a level of A for each component of a waste stream that appears as a known or anticipated carcinogen or reported as mutagenic by one test as recorded in the NTP. A component that does not appear on the NTP lists is considered non-toxic and is not evaluated unless it scores in one of the other toxicity categories.

TABLE 4-1. TOXICITY WEIGHTING TABLE

Weighting Factor Level	Chronic Toxicity	Aquatic (Fish) LD_{50} (ppm)	Oral (Rat) LD_{50} (mg/kg)	Inhalation (Rat) LC_{50} (mg/l)	Dermal (Rabbit) LD_{50} (mg/kg)
A	Known or anticipated carcinogen (NTP List) or mutagenic reported by NTP.	< 0.1	< 0.5	< 0.02	< 2
B	-	0.1-1	0.05-5	0.02-0.2	2-20
C	-	1-10	5-50	0.2-2	20-200
D	-	10-100	50-500	2-20	200-2,000
E	-	100-1000	500-5000	20-200	2,000-20,000

Toxicity data must then be obtained for each component of the waste stream using the same resources as in the special waste screen. Each component is assigned a weighting factor level for each of the five toxicity columns in the table. The highest weighting factor level of the five columns is assigned to that particular waste stream component. Each component in a waste stream is assigned a level (e.g., A, B, C, D, or E). Components that are rated below the lowest weighting factor level are not considered in this evaluation. When data are not available for one or more of the five toxicity columns, the highest weighting factor level available is used and the absence

of this data is noted on the evaluation form. When no information is available on a particular component, that component should be evaluated at the highest weighting factor unless the State regulatory agency grants an exemption for that particular component.

Rationale. The toxicity weighting table is adapted from the State of Washington Dangerous Waste Regulations. Five levels of toxicity are established for each of the acute and environmental toxicity categories. These levels were set by arranging the LC_{50} and LD_{50} values for each level at 10 times the next higher level. The values in each level vary from the adjacent levels by an order of magnitude and an assumption is made that each level is 10 times more toxic than the next lower level.

Only one level of toxicity was established for chronic toxicity. Carcinogenicity and mutagenicity cannot be quantified in the same way as acute and environmental toxicity where LC_{50} and LD_{50} values are available. The project team concluded that carcinogens and mutagens should be given special consideration in this evaluation. Therefore, any component that is listed on the NTP lists used in the Special Waste Screen will fall into the highest weighting category, A.

This approach for weighting carcinogens is considered to be the most feasible and defensible in light of the current availability of information on these substances. Ideally, special wastes containing carcinogens should be classified on the basis of potency and quantity. There are methods available assessing carcinogen potency, but this approach requires expertise that is usually not available at a reasonable cost to waste generators or review agencies. On-going regulatory activities by U.S. EPA may provide reliable informatin in the near future to allow classification of carcinogens according to potency and quantity.

4.3.1.1.2 Step B1b -- Equivalent Concentration Formula.

Decision Criteria. Using the assigned toxicity weighting factor levels the total equivalent concentration can be determined using the following equation:

$$\begin{array}{c}\text{Toxic}\\\text{Equivalent}\\\text{Concentration}\end{array}\ (\%) = \Sigma A\% + \frac{\Sigma B\%}{10} + \frac{\Sigma C\%}{100} + \frac{\Sigma D\%}{1000} + \frac{\Sigma E\%}{10{,}000}$$

The concentrations expressed as percent for all components in a waste stream at each toxicity level are added and applied to this equation. The sum at each toxicity level is divided by the appropriate weighting factor and the adjusted concentrations for each toxicity level are added together to attain the percent equivalent concentration.

Rationale. The equivalent concentration approach offers several advantages in the evaluation of complex waste mixtures. Each of the waste components is considered individually for its inherent toxicological properties but the resultant concentration for the waste stream represents a composite concentration. This approach assumes that the toxicity effects are additive and does not account for synergistic or antagonistic effects of the various components. It is not likely that all waste components will have 'additive' effects in the sense that each component will produce similar effects in a target organ. Nevertheless, the equivalent concentration is a feasible method of determining the relative toxicity potential of a waste in terms of waste component concentrations. The weighting scale consists of weighting factors that increase by an order of magnitude. These factors correspond to decreased potency in toxicity that also change by a factor of 10.

4.3.1.1.3 Step B1c -- Accumulative Toxicity Scoring Graph.

Decision Criteria. The percent equivalent concentration for accumulative toxicity of a waste stream is plotted versus the annual generation rate of that waste stream expressed in kilograms per month using the accumulative toxicity scoring graph. This graph is divided into four areas: 0, 1, 2, and 3. Three (3) represents a waste with high potential toxicity.

Two approaches were proposed for assigning scores. The first method was based on existing regulations (Figure 4-6). PCBs were selected as a representative substance that would be rated at the 'A' level of toxicity. The Toxic Substance Control Act (TSCA) does not regulate PCBs below 50 ppm (0.005 percent). The Resource Conservation and Recovery Act Amendments of

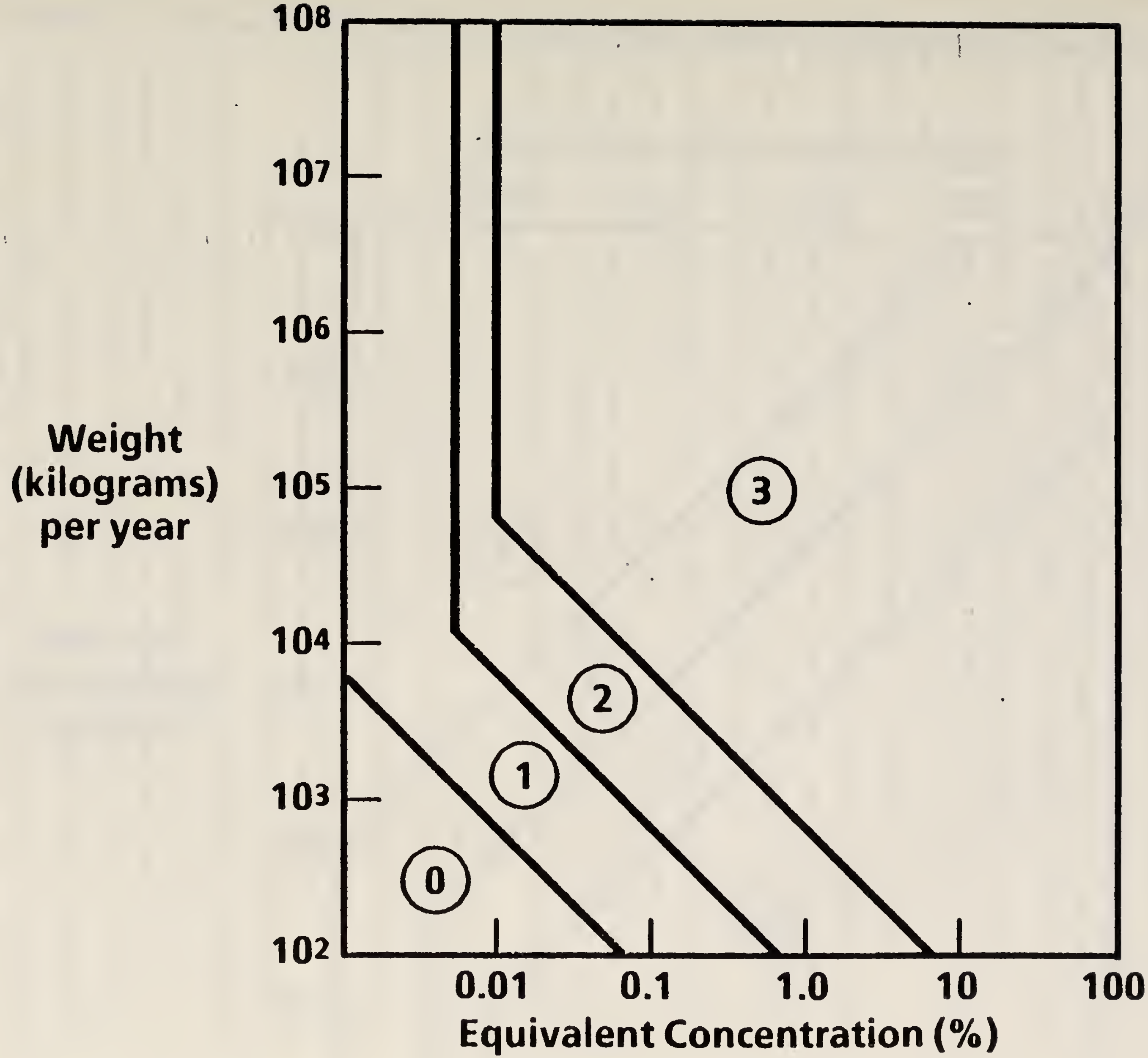


FIGURE 4-6. ACCUMULATIVE TOXICITY SCORING GRAPH (PCB/SMALL GENERATOR APPROACH)

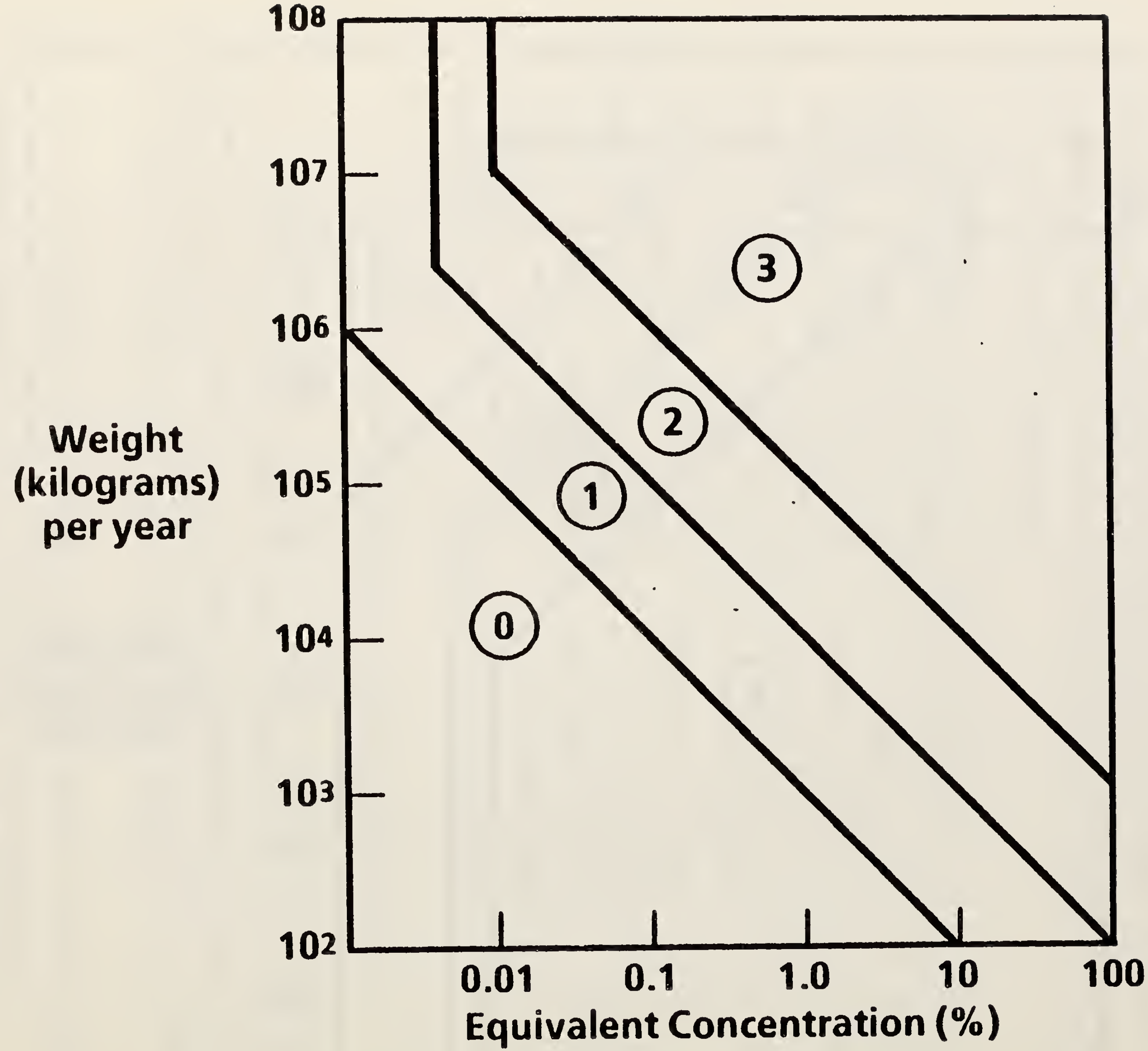


FIGURE 4-7. ACCUMULATIVE TOXICITY SCORING GRAPH (ARBITRARY DESIGNATION APPROACH)

1984 exempt generators of hazardous waste from the associated regulations if they generate less than 100 kilograms of waste per month. Assuming that a waste stream contains PCBs as the only toxic component and that they are present at approximately 50 ppm, an equivalent concentration for accumulative toxicity can be calculated of 0.005 percent. Also, assuming that this waste stream is generated at approximately 100 kilograms per month, it can be calculated that this would result in 0.5 kilogram of pure PCBs being generated each month in this waste stream. The line delineating the 0 and 1 accumulative toxicity scores is drawn based on 0.5 kilograms at various volumes of waste and corresponding equivalent concentrations adjusted to an annual generation basis. The remaining two lines were then plotted based on a factor of 10 times the preceding lines (5.0 and 50.0 kilograms). Based on this approach, Battelle plotted the waste streams being used in the implementation phase (see Chapter 5.0) and found that most wastes received scores of 2 or 3. A review of the scores by staff with expertise in toxicology and hazardous waste management indicated that this approach appeared to be overly conservation and to direct many wastes to the higher scores when in fact professional judgment suggested that lower scores were more appropriate.

The second approach was to arbitrarily set the lines on the scoring graph so that more of the wastes received lower scores (Figure 4-7). This method was consistent with the fact that RCRA wastes were not included with the set of sample wastes and one might expect many special wastes to be less toxic than RCRA wastes and therefore tend to receive lower scores.

However, it should be recognized that there may be disadvantages with the scoring graph approach in general. Scoring graph lines correspond to a specific quantity of a waste. For example, the 0/1 line in Figure 4-6 represents 0.5 kilograms of a waste. The assumption is made here that a release to the environment of 0.5 kilograms per month of a waste may cause adverse effects. Obviously, the allowable release quantity would change from one waste to another depending upon waste characteristics such as toxicity and persistence. By calculating an equivalent concentration for a complex mixture, it is believed that the concentrations of the components have been standardized so that each constituent contributes equally to the establishment

of a waste quantity that can then be evaluated on the scoring graph. At this time there are no data available to validate this approach.

An allowance was also made for waste streams in both approaches that had equivalent concentrations for accumulative toxicity of less than 0.01 percent. The project team felt that concentrations of toxicants lower than this level did not deserve the highest toxicity score (3). The lines on the graphs were therefore adjusted so that such waste streams would not score above a 2 for accumulative toxicity scores less than 0.01 and above 1 for scores less than 0.005 regardless of volume. This would make low volume waste streams that consist of primarily (99.99 percent) innocuous substances (i.e., sand or bentonite) and wastes that are slightly contaminated with toxic components easier to deal with in a rational manner.

<u>4.3.1.2 Step B2 Accumulative Environmental Fate Scoring</u>. An evaluation of physical and chemical factors is made of waste streams examining the tendency for components of a waste stream to solubilize, bioaccumulate and to persist over a period of time (Fig. 4-8). Waste streams which either the highest or lowest level (3 or 0) in accumulative toxicity need not be considered in the environmental fate evaluation; those at the highest level (3) are considered hazardous enough to pose an immediate danger to the environment, and those at the lowest level (0) are considered innocuous enough to be non-threatening. Such wastes are immediately routed to the treatment/disposal evaluation. Wastes which scored in the intermediate toxicity categories (1 or 2) need to be evaluated to assess what kind of impact they might have upon being released into the environment. The environmental evaluation is only conducted on the components of a waste stream that achieve a weighting factor level of A, B, C, D, or E on the accumulative toxicity weighting table. Components that are not sufficiently toxic to be rated on that table are not considered in the environmental fate evaluation.

The proposed system operates on the principle that special wastes with an accumulative toxicity socre of 3 or 0 are not required to be evaluated in the environmental fate analysis and receive a toxicity hazard rating of

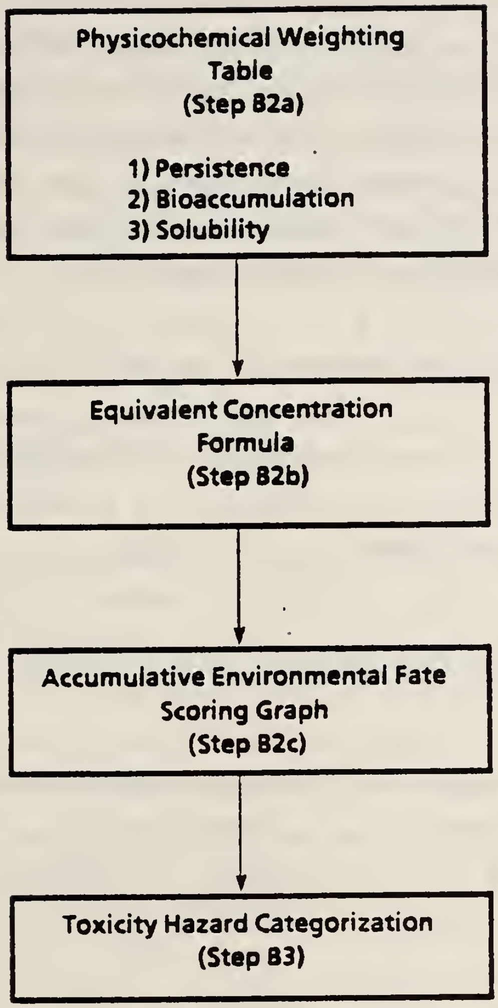


FIGURE 4-8. ACCUMULATIVE ENVIRONMENTAL FATE SCORE (STEP B2)

"high" or negligible, respectively. The basis for this approach is two-fold. It was concluded that wastes with an accumulative toxicity score of 3 by virtue of toxicity and quantity should be regarded as highly toxic regardless of its environmental fate properties, since these special wastes could pose an occupational health hazard as well as a potential public health hazard. On the other hand wastes with an accumulative toxicity score of zero does not pose a significant health hazard and characteristics such as mobility persistence or bioaccumulation are of lesser importance.

4.3.1.2.1 Step B2a Environmental Fate Weighting Table.

Decision Criteria. The environmental fate weighting table (Table 4-2) is used to rate each toxic component of a waste stream for bioaccumulation tendency, persistence and solubility.

TABLE 4-2. THE ENVIRONMENTAL FATE WEIGHTING TABLE

Level	Bioaccumulation (log P)	Persistence ($T_{1/2}$, soil or water)	Solubility (ppm Water)
A	≥6	≥10 years	500+
B	5 - <6	1 year - <10 years	100-499
C	4 - <5	1 month - <1 year	50-99
D	3 - <4	3 days - <1 month	10-49
E	<3	<3 days	<10

Bioaccumulation is measured as the log 10 of the n-octanol/water partition coefficient (log P). Persistence is measured as the half life of the chemical in soil or water ($T_{1/2}$). Log P values can be found in many standard chemistry reference manuals (Verschueren Handbook, Merck). Values for $T_{1/2}$

may be more difficult to obtain; therefore general chemical groups and their relative persistence in the environment have been provided in Table 4-3 and can be used when half-life data are not available. Solubility refers to the solubility of a substance in water. Solubility values can be obtained from standard chemistry reference manuals (CRC, Seidell, Lange).

The highest weighting factor level of the three characteristics is assigned to each toxic component of a waste stream. If information is not available for one of the environmental fate characteristics then one of the other values is used in the evaluation and a note is made on the work form. If information is not available on any characteristic then level A is assigned to the component unless the State regulatory agency grants an exemption for a lower level to the generator.

Rationale. Bioaccumulation is currently viewed as the tendency of a substance to transfer from water to the lipid (fatty) phase of an organism. It is related to the value of P, the n-octanol/water partition coefficient (Chiov et al., 1977). P is frequently reported as a base 10 logarithm, log P. (The constants P and log P are frequently referred to in the literature as K_{OW} and log K_{OW}). n-Octanol is generally accepted as a good medium for simulating natural fatty substances (Tulp and Hutzinger, 1978).

Highly bioaccumulative compounds have log P values greater than 5.0. For example 4,4'-PCB; p,p'-DDE; 2,4,5,2',5'-PCB; p,p'-DDT; and leptophos have log P values of 5.58, 5.69, 6.11, 6.19, and 6.31, respectively. Compounds which bioaccumulate to a lesser degree, such as monochlorobenzene, tetrachloroethylene, dicapthon, and diphenyl ether have log P values of 2.18, 2.60, 3.58, and 4.20, respectively (Michigan Department of Natural Resources, 1980).

The log P values extracted directly from literature sources are the preferred data to rate bioaccumulation. If log P values are unobtainable, however, the log P value for organic substances can be approximated using the following equation:

$$\log P = 5.00 - 0.67 \log S$$

where S is the aqueous solubility (preferably at 25C) in μmole/L and P is the n-Octanol/water coefficient (Tulp and Hutzinger, 1978).

TABLE 4-3. ALTERNATE WEIGHTING TABLE FOR PERSISTENCE

Weighting Factor Level	Persistence $T_{1/2}$, Soil or Water	Waste Stream Components
A	> 10 years	Heavy metals, inorganic oxides, inorganic salts, asbestos, clays, plastics, polymers
B	1-10 years	Pesticides, halogenated hydrocarbons, phthalate esters, polyaromatic hydrocarbons, biphenyls, paper products, oils, fats, greases, resins, pigments
C	1 month-1 year	Simple nonhalogenated benzenes, nonhalogenated cyclic hydrocarbons, nonhalogenated straight chain and branched hydrocarbons (< 10 carbons)
D	3 days-1 month	Nonhalogenated straight chain and branched hydrocarbons (≥ 10 carbons)
E	≤ 3 days	Nonhalogenated, oxygen containing simple hydrocarbons (1-4 carbons)

The persistence of a chemical substance is related to the chance of exposure of an organism to the substance. It is measured as the value of $T\frac{1}{2}$, the half-life (in soil or water). Highly persistent species which remain unchanged in the environment for a period of time on the order of years are exemplified by inorganic ions (e.g., Na^{+}, Fe^{3+}, Cl^{-}) and halogenated organics (e.g., aldrin, chlordane, DDT, and PCB). Low persistence implies much less ambient stability and are characterized by simple organics which are easily digested by the environment (e.g., acetone, acetophenone, ethanol, and pentadecane) (Abrams et al., 1975).

Aqueous solubility is a measure of the ability of a substance to dissolve in water. Once dissolved the substance can then move through the environment and may eventually expose humans and other populations.

When the choice of solubility in either cold or hot water is encountered, the hot-water (100F) solubility is the preferred data. This is due to the fact that hot-water solubility data is generally reported at a water temperature of 100F while cold-water temperatures are reported with much less consistency.

<u>4.3.1.2.2</u> Step B2b Equivalent Concentration Formula.

<u>Decision Criteria</u>. After each toxic component of a waste stream is assigned a weighting factor level the following equation is used to calculate an equivalent percent concentration for the waste stream.

$$\begin{array}{l}\text{Environmental Fate}\\ \text{Equivalent (\%)}\\ \text{Concentration}\end{array} = \Sigma A\% + \frac{\Sigma B\%}{10} + \frac{\Sigma C\%}{100} + \frac{\Sigma D\%}{1000} + \frac{\Sigma E\%}{10{,}000}$$

<u>Rationale</u>. The equation is designed to weight the more persistent bioaccumulative or soluble components in exactly the same manner as the equation used in the accumulative toxicity evaluation utilizing a factor of 10 between levels.

4.3.1.2.3 Step B2c Accumulative Enviromental Fate Scoring Graph.

Decision Criteria. The equivalent concentration as percent for environmental fate characteristics is then plotted on the environmental fate Scoring Graph. This results in an accumulative Environmental Fate score of 0, 1, 2, or 3 with 3 being the highest and 0 the lowest.

Rationale. Two approaches were utilized for developing the Accumulative Environmental Fate Scoring Graph. These were the same approaches used in development of the Accumulative Toxicity Scoring Graph. The first approach was based on PCBs and the small quantity generator rule in RCRA (Figure 4-9). This approach was found to cause most wastes to be categorized at the highest level. After careful review of these waste stream by scientists and engineers it was decided that the PCB/small quantity generator approach was much too conservative. The second approach (Figure 4-10) was based on an arbitrary assignment of scoring lines. This was the approach used to evaluate waste streams in Chapter 5.0.

4.3.1.3 Step B3 Toxicity Hazard Categorization.

Decision Criteria. Toxicity and environmental fate scores, calculated in the previous two sections, are used in this section to determine the appropriate degree of hazard category. Figure 4-11 (Toxicity Hazard Categorization Graph) is used to determine degree of hazard. The figure contains toxicity and environmental fate scores ranging from zero to three. Moving from left to right on the scoring graph, scores obtained previously are matched with the corresponding numbers on the tree until a hazard category of High, Moderate, Low, or Negligible is determined. Examples:

1. If toxicity scores of three or zero have been obtained, the degree of hazard scores, without considering environmental fate scores, are automatically High Hazard and Negligible Hazard, respectively. Looking at the scoring tree, note that toxicity scores of three and zero are above horizontal lines which do not intersect a vertical line in the Environmental Fate Score column,

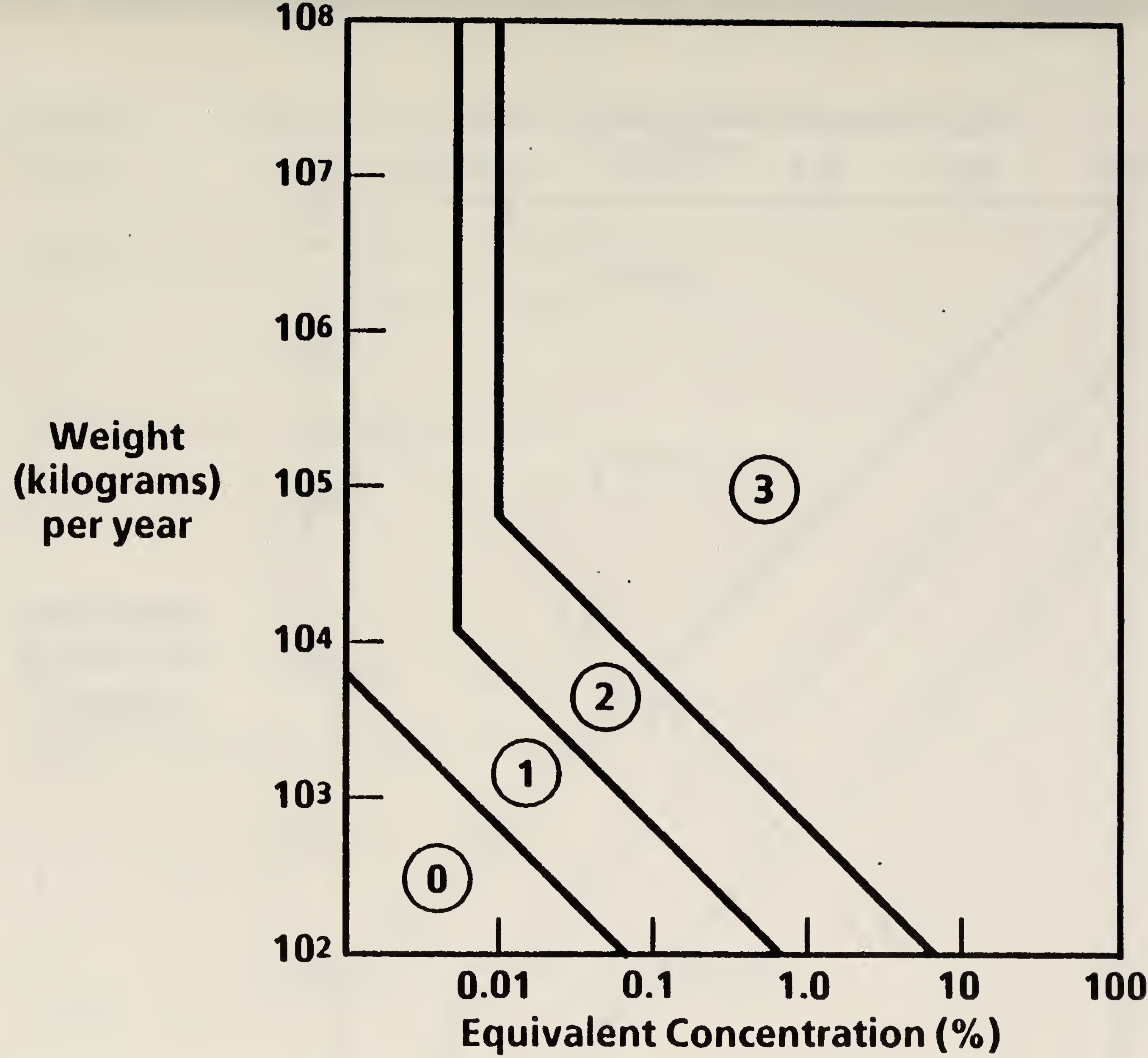


FIGURE 4-9. ACCUMULATIVE ENVIRONMENTAL FATE SCORING GRAPH (PCB/SMALL GENERATOR APPROACH)

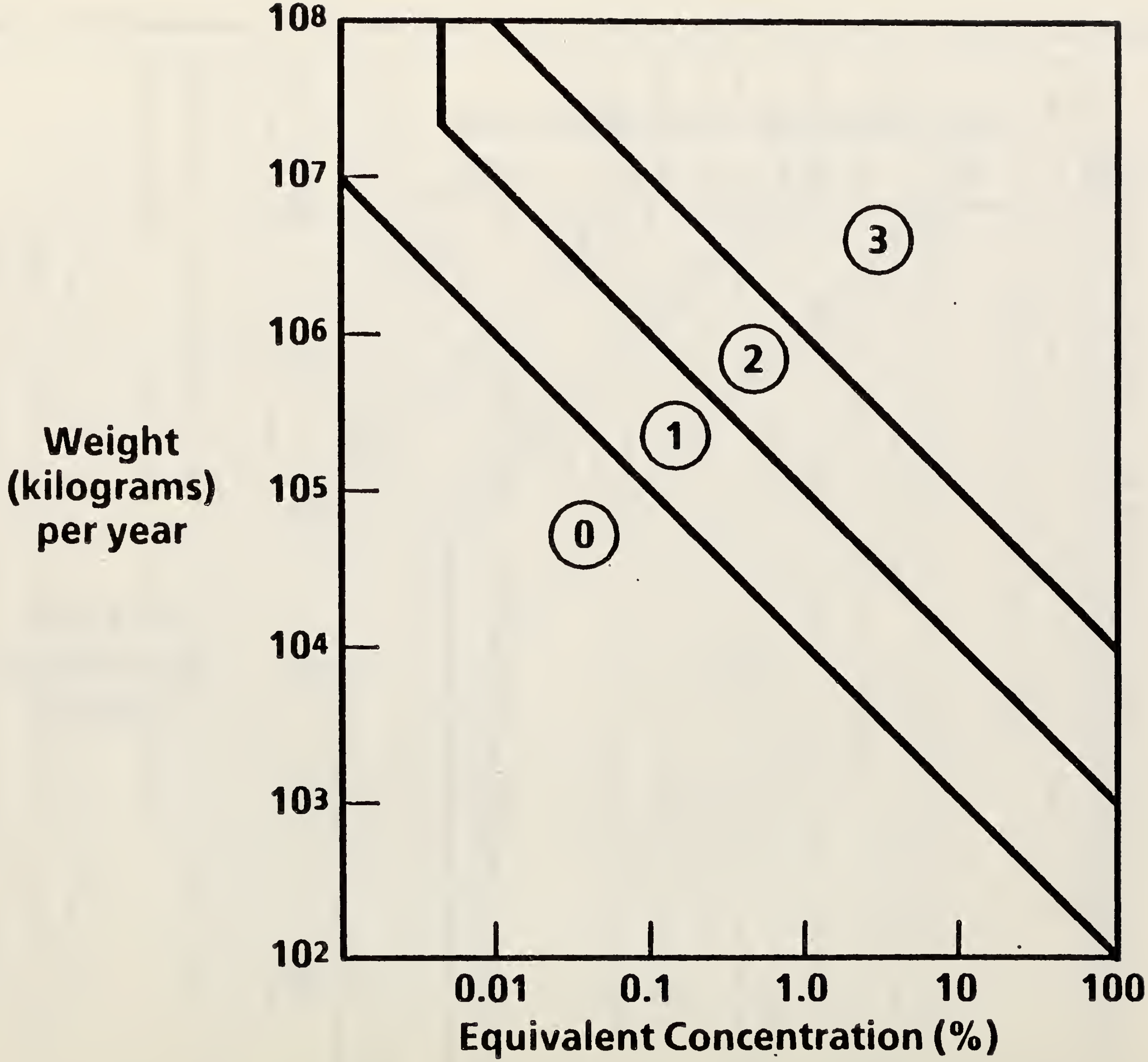


FIGURE 4-10. ACCUMULATIVE ENVIRONMENTAL FATE SCORING GRAPH (ARBITRARY DESIGNATION APPROACH)

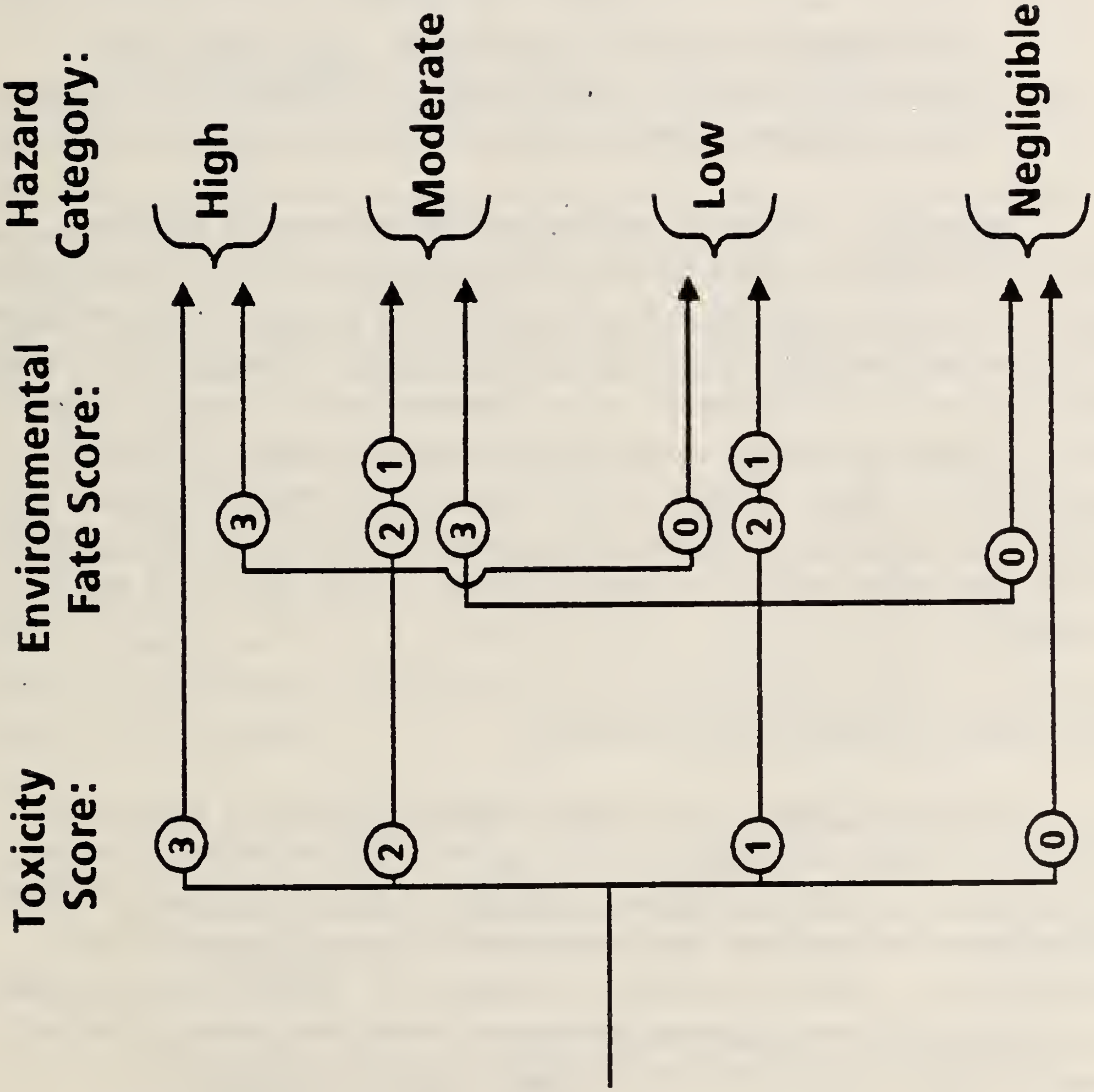


FIGURE 4-11. TOXICITY HAZARD CATEGORIZATION GRAPH (STEP B3)

but proceed directly to Toxicity Hazard Categorization. In other words, environmental fate scores are irrelevant when toxicity scores are three or zero. When determining the Hazard Category for chemicals with toxicity scores of two and one, however, the environmental fate score must also be considered before a hazard category is determined.

2. A toxicity score of two and a environmental fate score of zero have been obtained. A score of two is located in the Toxicity Score column, moving from left to right, the Environmental Fate Score column is intersected. The vertical line is followed until environmental fate scores are matched; in this case, move downward to the zero. Finally, proceed horizontally to the right into the Hazard Category column to achieve a Low Hazard Score.

Rationale. A properly designed scoring system is an effective method for designating a waste against its characteristics. This scoring tree is based on the most important properties of a waste stream. The accumulative toxicity and environmental fate components of the score encompass waste stream volume; weighted concentrations of toxic components and environmental fate factors. A waste is assigned an appropriate degree of hazard. This designation provides a better safeguard of public and environmental health, a more organized and effective regulation process, and an emphasis on proper management for those wastes posing the greatest threat to both the public and the environment.

4.3.2 Step C -- Disease Hazard Evaluation

Decision Criteria. The Disease Hazard Evaluation is based on the definition for "Hazardous Hospital Waste" as it appears in Illinois Regulations (Title 35, subtitle G, Chapter I, 809.901). This is the same definition used for the infectious waste part of the Special Waste Screen (Step A6). This definition is found in Table B-3 of Appendix B. Whenever a waste stream fits this definition it is considered to have a high disease hazard and must be handled accordingly (Table 4-4). Volume is not considered in this evaluation.

Rationale. Disease hazard based on infectious characteristics is an important aspect of the overall hazard evaluation of a waste. This is particulary true for handling of the waste during collection, storage, transportation and final disposal. Volume is not considered because pathogens may be present in high numbers in very small amounts of waste material and could therefore present a real danger to anyone handling the waste. The Illinois legislature deemed these wastes to be hazardous enough to pass legislation regulating their handing.

4.3.3 Step D -- Fire Hazard Evaluation

Decision Criteria. Fire hazard is determined based on the definitions for ignitable and flammable waste that are used in the Special Waste Screen (Steps A7 and A8). The ignitability definition applies to liquids and is determined using a Pensky-Martens Closed Cap Tester and the method specified in ASTM Standard D-39-79 or D-93-80. Any liquid that has a flashpoint at or above 140F (60C) and below 200F (93.3C) is considered ignitable and will present a fire hazard during handling and disposal. The degree of this hazard is determined from the Hazard Categorization Volume Table (Table 4-4).

Solid materials cannot be tested in this manner and therefore a widely accepted definition for flammability is used to determine fire hazard. This definition is used by the U.S. Department of Transportation (USDOT) and is the same definition used in the Special Waste Screen. According to the DOT, a "flammable solid" is any solid material, including gels and pastes, other than one classed as an explosive or a blasting agent, which is described as one of the following:

(a) Pyrophoric solids which ignite when exposed to moist air at or below 55C (130F), or

(b) solids subject to spontaneous heating by reaction with oxygen and which contain unsaturated oils or other easily oxidizable substances, or

(c) solids subject to spontaneous heating by fermentation or bacterial action and which self-heat due to the action of bacteria or other organisms, or

(d) readily ignitable solids which are easily ignited and burn so vigorously and persistently as to create a hazard in transportation, or

(e) solids which can be ignited by friction, or

(f) solids which in contact with water evolve flammable gases, or

(g) solids or molten materials shipped at (elevated) temperatures exceeding 315C (600F), which can cause ignition of combustible materials.

Tests used to evaluate the above descriptions are described in the Federal Register, 1981, May 7, Vol. 46, No. 88, p. 25493 (Figure B-2, Appendix B). Any solid waste material that conforms with the definition is considered to present a fire hazard. The degree of this hazard is determined using the Hazard Categorization Volume Table (Table 4-4).

Rationale. Fire hazard based on ignitability and flammatility are important from the aspects of handling, transportation, storage and particularly landfilling. Although these wastes would not be defined as hazardous under RCRA they still present a fire hazard during handling. Landfill fires have become more common and when flammable materials are disposed of in proximity to various other hazardous wastes the danger is compounded.

4.3.4 Step E -- Leaching Agent Hazard Evaluation

Decision Criteria. A waste material is considered to be a potential leaching agent when its pH upon disposal is less than 4.0 (acidic) or greater than 10.0 (alkaline). The degree of hazard of such a material is determined from the Hazard Categorization Volume Table (Table 4-4).

Rationale. Although these pH ranges may not be corrosive and therefore dangerous in handling, they are of concern in land disposal operations. The waste material itself may not be toxic, but it may be land disposed in proximity with other toxic materials that are highly prone to leaching at high or low pH (e.g. heavy metals). Liquids present in the landfill could contact

the low or high pH material and subsequently move through the fill area with a much lower or higher pH. This leaching of toxic materials is significant from the standpoint of ground and surface water contamination.

4.3.5 Step F -- Biological Characteristics Evaluation

Decision Criteria. A waste stream is considered to have adverse biological characteristics when it is a liquid, solid, semisolid or gaseous waste generated by humans, animals or plants as a direct or indirect results of the manufacture of a product or the performance of a service and could result in:

(1) generation of a leachate that has a high biological oxygen demand,
(2) generation of gases such as methane or hydrogen sulfide,
(3) attraction of vector type organism such as rats, flies and other vermin or
(4) generation of offensive odors.

Biological waste, includes but is not limited to, biological pond sludge, animal rendering waste, vegetable by-products, meat packing waste, food processing waste and hydrolyzed vegetable protein.

The degree of hazard for such a waste is determined from the Hazard Categorization Volume Table (Table 4-4).

Rationale. Biological wastes may not be infectious but may still present a real or potential threat to human health or the environment. They also possess properties which make disposal in a landfill difficult to manage by normal means. Therefore, this evaluation is an important and needed step in the overall evaluation of a waste stream.

TABLE 4-4. HAZARD CATEGORIZATION VOLUME TABLE

Hazard Factor	Volume (kg)	Hazard Category
Disease	any volume	High
Fire	>1200 <1200	High Low
Leaching Agent	>1200 <1200	Moderate Low
Biological	>100,000 10,000-100,000 <10,000	High Moderate Low

4.4 Summary of Procedures and Information Requirements

Detailed information about the chemical composition of the waste stream is obtained from applications and permits. This information needs to be specific at the elemental and compound level because toxicity and environmental fate information is generally organized this way too.

One begins with the first question in the screen. Is any component of the waste stream carcinogenic or mutagenic? If the answer is yes to any one component, the evaluation, according to the National Toxicology Program list, may stop and go to the Degree of Hazard Evaluation part of the system. If no is the answer, we go to the next question. Does any component of the waste stream have an LD_{50} less than 5000 mg/kg? If yes, then we go to the Degree of Hazard Evaluation. If no, we go to the next question and repeat the process. It is possible to get a no answer at every major question which would imply an innocuous stream. It is anticipated that most streams will have a component that triggers a yes answer and that further evaluation of that stream will be required.

In the Degree of Hazard Evaluation part of the system the emphasis is on the total stream as opposed to a component by component approach. Also, the emphasis is on graded numerical output whereas the screen assesses each component with a definitive yes and no approach.

The first question in the Degree of Hazard Evaluation is one about chronic toxicity. What components are carcinogenic or mutagenic? If a component is carcinogenic then it is assigned a high toxicity level (A) and no more work needs to be done for that substance on the broad topic of toxicity. For every substance that is not carcinogenic, further work is needed on various forms of aquatic and mammalian toxicity. Toxicity information for inhalation, ingestion and dermal routes of exposure are compiled and a toxicity category is assigned to each component.

For each component we select the highest level rating (in the order A, B, C, D, E) and apply the formula:

$$EC = A\% + \frac{B\%}{10} + \frac{C\%}{100} + \frac{D\%}{1000} + \frac{E\%}{10,000}$$

Next, we convert the stream volume into kilograms per year. After finding the point on the toxicity scoring chart, the toxicity score is determined as being 0, 1, 2, 3, where 3 is the high volume/high toxicity wastes. If the score is 0 or 3 we go to the next hazard question. If the toxicity score is 1 or 2 there is another step, the environmental fate evaluation. In the environmental fate evaluation the first question pertains to the persistency of each toxic substance in the waste stream. For inorganics this is generally the highest level, A. If the highest score is not obtained as is the case with many organics, then questions about bioaccumulation and solubility in that order are asked. The environmental fate equivalent concentration is determined with the above formula. The volume has already been computed. The intercept of the equivalent concentration and volume results in the environmental fate score (0, 1, 2, 3).

The toxicity score and environmental fate score are used to determine the degree of toxicity hazard per the listed combinations of 3s, 2s, 1s and 0s.

The next step in the procedure is to recognize additional attributes of the waste. These are biological characteristics hazard, disease hazard, fire hazard and leaching agent hazard. They are the same basic questions being asked in the screen. Once these answers are obtained, one is ready to match the information with a table on disposal options and recommend the preferred disposal techniques for that particular waste stream.

A summary of all of the steps in the Illinois Special Waste Classification System is found in Table 4-5. Also, Table 4-6 contains a list of the steps, the type of information needed and major sources of information.

TABLE 4-5. SUMMARY OF STEPS IN THE ILLINOIS SPECIAL WASTE CLASSIFICATION SYSTEM

Step
I. Special Waste Screening Evaluation
A Special Waste Screen
A1 RCRA Hazardous Waste
A2 Chronic Toxicity
A3 Acute Toxicity
A4 Environmental Toxicity
A5 Biological Characteristics
A6 Infectious Characteristics
A7 Ignitability (liquids)
A8 Flammability (solids)
A9 Leaching Agent Characteristic
A10 Illinois Review
II. Degree of Hazard Evaluation
B Toxicity Hazard Evaluation
B1 Accumulative Toxicity Score
B1a Toxicity Weighting Table
o Chronic Toxicity
o Aquatic Toxicity
o Acute Toxicity
B1b Equivalent Concentration Formula
B1c Accumulative Toxicity Scoring Graph
B2 Accumulative Environmental Fate Score
B2a Environmental Fate Weighting Table
o Persistence
o Bioaccumulation
o Solubility
B2b Equivalent Concentration Formula
B2c Accumulative Environmental Fate Scoring Graph
B3 Toxicity Hazard Categorization

TABLE 4-5. (Continued)

Step
C Disease Hazard Evaluation
C1 Definition of Infectious Waste
C2 Volume Table
D Fire Hazard Evaluation
D1 Temperature Limits
D2 Volume Table
E Leaching Agent Hazard Evaluation
E1 pH Limits
E2 Volume Table
F Biological Characteristics Evaluation
F1 Definition of Characteristics
F2 Volume Table
III. Treatment/Disposal Evaluation

TABLE 4-6. SUMMARY OF STEPS, INFORMATION NEEDS AND INFORMATION SOURCES FOR THE CLASSIFICATION SYSTEM

Name	Step Number	Type of Information Needed	Major Source of Information
RCRA Hazardous Waste	A1	Definition of hazardous waste	40 CFR 261
Chronic Toxicity	A2, B1	Does the component elicit a carcinogenic or mutagenic effect in animals or humans?	National Toxicology Program Annual List of Carcinogenic and Annual Summaries of Mutagenicity
Acute Toxicity	A3, B1	LD_{50} data for oral, dermal exposure on mammals	Registry of Toxic Effects of Chemical Substances and General Literature
Environmental Toxicity	A4, B1	LC_{50} data for fish	General Literature
Biological Waste	A5, F	Potential for creating high biological oxygen demand	Waste stream: presence of oils & materials of biological origin the waste
Infectious Waste	A6, C	Potential for infection and disease from pathogens	Waste stream: presence of material of human contact
Ignitable	A7, D	Flashpoint at or above 140F and at or below 200F	Waste stream: Flashpoint test
Flammable Solid Wastes	A8, D	USDOT definition for flammable solid	Waste stream: general knowledge for testing
Leaching Agent	A9, E	pH less than 4 and greater than 10	Waste stream: pH testing
Persistence	B2	Half-life of the chemical in soil or water ($T_{\frac{1}{2}}$)	General literature and Table 4-3
Bioaccumulation	B2	Log 10 of the n-octanol/water partition coefficient (log P)	Verschueren Handbook, Merck
Solubility	B2	Solubility in water	CRC, Seidell, Lange

5.0 SYSTEM IMPLEMENTATION AND EXPERIENCE

The purpose of this section is to present how the classification system works, using various examples of waste streams. First, a brief evaluation of waste streams will be presented with emphasis on elimination of duplicate waste streams and near duplicates, and on selection of a variety of waste streams for implementation. An example waste stream is taken through the steps in the system to show how to follow the procedure. There are two groups of waste streams. The first group consisting of 238 was put through the screen only and the second group consisting of 30 was put through not only the screen but the degree of hazard evaluation and linked to the disposal option. An overview of the major findings will be provided that emphasizes that the classification system works when adequate information is available. Finally, a master summary table is presented showing which waste streams were eliminated and which were used to various extents in this "proof of concept" section.

5.1 Evaluation of Waste Streams

Battelle personnel were requested to: (1) look over the short printout list (264 wastes) of special wastes that had been provided by Illinois ENR to determine their representativeness and adequacy for use in the waste classification study, and (2) to cull about 50-60 wastes from the list to allow ENR to provide additional waste streams which are to be derived from different waste lists or sources at ENR for inclusion in the study. We also reviewed the list of wastes and determined that once the eliminated wastes were replaced, it provided a diverse and representative sample of wastes to put through the classification system.

The first criterion that was employed in the review process was to eliminate those waste streams which were considered to be essentially "exact duplicate" wastes. These generally were wastes that were designated as coming from the same generator, with essentially the same "genname" and process source as well as possessing similar compositions and properties. The wastes which fell into the essentially "exact duplicate" category are shown in Table 5-1.

TABLE 5-1. ESSENTIALLY "EXACT DUPLICATE" WASTES FOR REMOVAL FROM THE ENR SHORT LIST OF 264 SPECIAL WASTES

Waste Number	Waste Description (Genname)
26	Cinders
36	Contaminated Asphalt Feedstock
39	Cranberry and Prune Waste
45	Diatomaceous Earth Filter Cake
54	Filter Cake Sludge
74	Fullers Earth Filter Media
80	Grease/Sludge
115	Nickel Carbonate
120	Oil Sludge
136	Polymer Waste Water
140	Processing Waste
156	Shampoo Waste
158	Sludge
165	Soapy Rinse Water
168	Soluble Oils and Water
172	Spent Bleaching Earth
197	Waste Copper Solution
200	Waste Dug Pot Lining
215	Waste Oil
216	Waste Oil

A second category or group of wastes selected for elimination from the short list was based on: (1) the wastes being near duplicates, i.e., generally similar to other wastes in the original list of 264 to be retained, and (2) the data provided for the wastes were considered to be too limited, vague, or analytically suspect to allow their meaningful use in the overall waste categorization study.

The list of wastes that were placed into the "near-duplicate/inadequate-data" category is presented in Table 5-2. It will be observed readily that "waste oil" wastes from various sources account for the bulk of wastes put into this second category. In instances where two or more wastes had generally similar compositions and properties, the wastes that were selected for culling were those considered to provide less meaningful data or had suspect analytical data reported for them than did the wastes retained on the list.

A total of 58 wastes was eliminated from the original short list of 264 special wastes provided by ENR, leaving 206 wastes for further consideration. Of the 58 wastes eliminated, 20 were in the essentially "exact duplicate" category, and the other 38 were in the "near-duplicate/inadequate data" category. Later, data on another 20 and then another 6 waste streams were made available by ENR to Battelle. These supplemental wastes were combined with the 206 wastes currently remaining on the original ENR list and reviewed further to arrive at a final total of 232 special wastes to be run through the screen part of the waste classification system developed in Section 4.

It was agreed that Battelle would run about 30 of the 232 waste streams through the screen and Degree of Hazard Evaluation to the disposal option. These wastes were to provide a mix of high/low volume, high/low toxicity (based on generator data), single/multiple components, and various physical states. They were meant to be reasonably representative of the wide range of special wastes generated in Illinois. The 30 were to be obtained in two ways. Twenty-four were to be selected from the 206 wastes and 6 were to be assigned by Illinois.

TABLE 5-2. NEAR DUPLICATE/INADEQUATE DATA CATEGORY OF WASTES FOR REMOVAL FROM THE ENR SHORT LIST OF 264 SPECIAL WASTES

Waste Number	Waste Description (Genname)
28	Clarifier Sludge
40	Crank Case Oil
50	Draw Off Water
66	Foundry Sand
68	Foundry Sand
83	Grinding Swarf and Oily Air Filter
85	Hog Hair and Paunch Residue
88	Humin Press Cake
95	Latex
108	Mixed Solid Waste
183	Used Lube Oil
185	Used Tube Oil
205	Waste Oil
206	Waste Oil
207	Waste Oil
209	Waste Oil
210	Waste Oil
213	Waste Oil
218	Waste Oil
220	Waste Oil
221	Waste Oil
222	Waste Oil
223	Waste Oil
224	Waste Oil
225	Waste Oil
226	Waste Oil
227	Waste Oil
228	Waste Oil
229	Waste Oil
231	Waste Oil
232	Waste Oil
233	Waste Oil
236	Waste Oil
237	Waste Oil
239	Waste Oil
241	Waste Oil
242	Waste Oil
263	White-Brown Benthone Proc. Mud.

We used 4 criteria to select a variety of waste streams from the 206 waste streams. These criteria are designed to identify a relatively large group (more than 20) of streams that could be considered typical ones. The criteria were:

(1) Stream complexity measured as the number of listed components on the printout. Preference was given to streams with 1, 3, and 5 listed components in order to get a range of conditions.

(2) Toxicity rating measured as the 1, 2, 3 values on the printout where 1 = least toxic, 2 = moderately toxic, and 3 = most toxic. There were some simple rules to govern further selection; preference was given to 11, 22, and 33 combinations.

(3) The third criteria was the magnitude of the waste stream. Units of measure were gallons and cubic yards. Preference was given to small and large waste streams. Small means less than 100,000 gallons and less than 2,000 yd^3. Large means greater than 350,000 gallons and greater than 5,000 yd^3. The range of conditions was 385 to 3,710,200 gallons and 16 to 106,840 yd^3.

(4) Next, tentative disposal options were considered on the remaining waste streams. Landfill, incineration, resource recovery, and physical/chemical treatment were considered with preference to a balance of disposal techniques.

The application of these four criteria to the 206 waste streams resulted in 24 streams. They are listed on Table 5-3. In addition, ENR provided 6 waste streams listed on Table 5-4.

5.2 Working Example

Once the 30 waste streams were identified each followed a sequence of analysis per the method described in Section 4.0. First, a chemical profile was obtained from printouts and other sources from the State of Illinois. In some cases, Battelle supplemented this information. The chemicals and other attributes of each stream were passed systematically through the screen and the Degree of Hazard Evaluation and then linked to disposal options. To

TABLE 5-3. LIST OF WASTE STREAMS TO BE IMPLEMENTED IN THE DEGREE OF HAZARD EVALUATION

Waste No.	Waste Description (Genname)
31	Coal ash
34	Composite paint sludge
42	Dewatered lime sludge
44	Diatom earth filter cake
67	Foundry sand
72	Fuller's earth
78	Grease, scum, floatable material
79	Grease/sludge
94	Kitchen grease catch basin
107	Mixed solid waste
112	Neutalized gasoline cracking
113	Neutralized salts brine solution
117	Oil contaminated materials
124	Oily sludge
132	Plating treatment sludge
134	Poly-isocyanurate foam board
135	Polymer waste water
153	Scum from skimmings
154	Sewage sludge
192	Used oils
193	Vacuum filter cake sludge
211	Waste oil
244	Waste oil tank #2-6
260	Water and oil waste

TABLE 5-4. LIST OF WASTE STREAMS TO BE IMPLEMENTED IN THE DEGREE OF HAZARD EVALUATION

Waste No.	Waste Description (Genname)
51 extra	Foundary sand
59 extra	Incinerator ash
79 extra	Metal hydroxide sludge
98 extra	Oil and water waste
151 extra	Paint sludge
330 extra	Wastewater treatment sludge

Extra means that the numbers assigned to the waste stream are redundant with the short printout

better explain how the system works, the steps involved in a particular waste stream analysis and classification will be presented. Waste stream no. 192, one of the representative streams, was selected for this purpose. A simplified classification flowchart for this waste stream is presented in Figure 5-1.

Information about the chemical constituents was extracted from a March, 1985 printout of 264 waste streams. The genname of "oils" was used; the proname (product name) was waste oil pick-up; and the volume was 531,155 gallons. There was one principal component: used oils at 100 percent. Subsequent information from the State of Illinois did not reveal more detailed information. Thereafter, Battelle advanced a list of likely constitutents and likely concentrations as follows:

Name Inorganics	Composition (%)
$AlCl_3$	0.004
$CdCl_2$	0.0001
$CrCl_3$	0.0007
Pb(Acetate)	0.11
Zn(Acetate)$\cdot 2H_2O$	0.08
Organics	
Benz(a)anthracene	0.0015
Benzene	0.007
Benzo(a)pyrene	0.0005
Dibutylphthalate	0.005
p-Dichlorobenzene	0.0005
Naphthalene	0.0460
PCB (Aroclor 1254)	0.0002
Phenanthrene	0.02
Phenol	0.0025
Tetrachloroethylene	0.04
Toluene	0.31
1,1,1-Trichloroethane	0.07
Trichloroethylene	0.06

The beginning step (A1) in the State of Illinois Special Waste Screen was to ask: Is it a RCRA Hazardous Waste? By definition, the answer is no. Step A2 deals with chronic toxicity: Is any component carcinogenic or

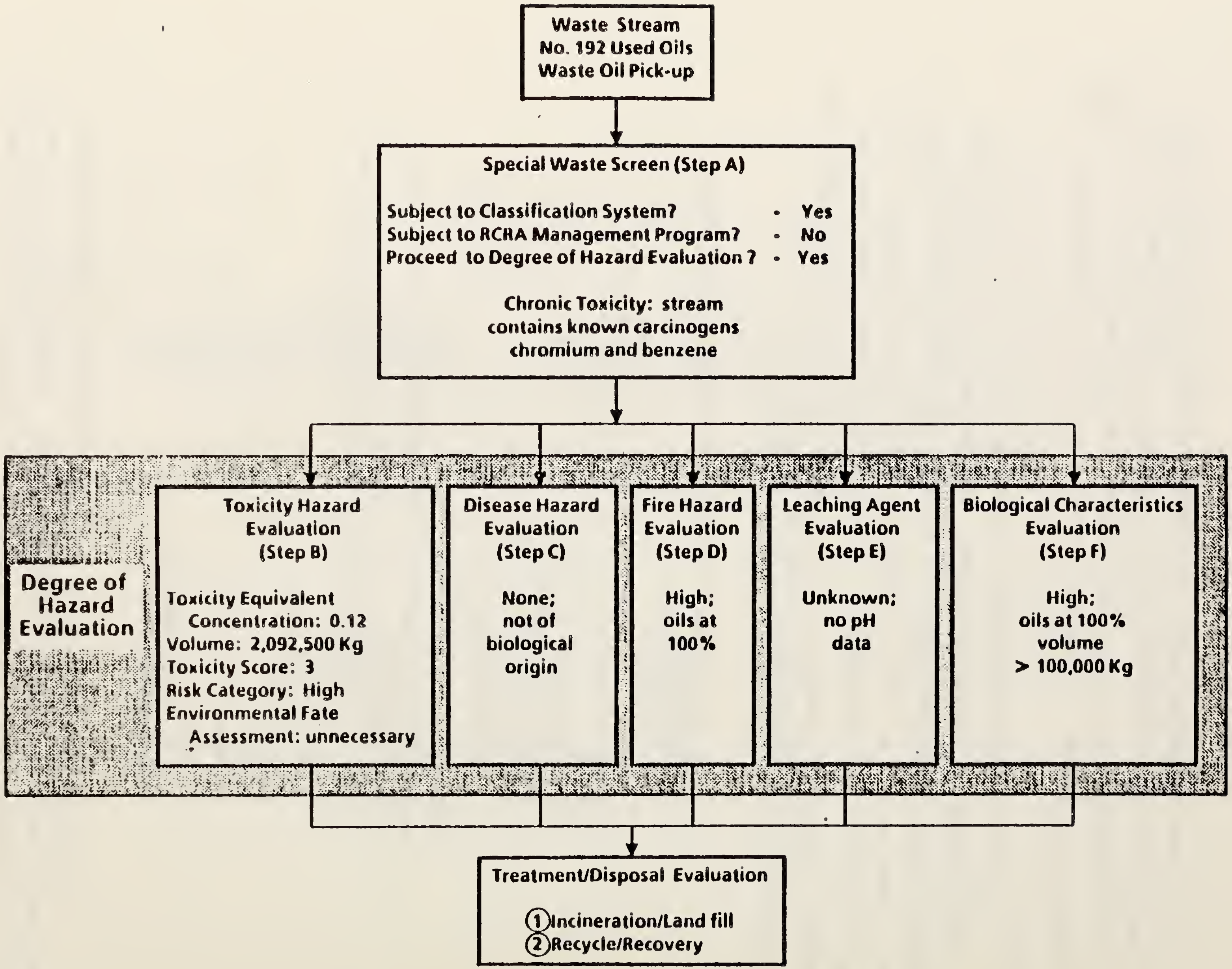


FIGURE 5-1. SIMPLIFIED CLASSIFICATION FLOWCHART FOR WASTE NO. 192

mutagenic? The answer is yes. At minimum, cadmium, chromium, and benzo(a)-pyrene are anticipated carcinogens. Thus, the stream goes to the Degree of Hazard Evaluation for further analysis. If the answer had been no, one would proceed to Step A3 and ask questions about Acute Toxicity.

In the Degree of Hazard Evaluation part of the classification method, questions are more detailed and focus on the entire waste stream. Chemicals are evaluated in the Accumulative Toxicity step (Step B1). Every component is addressed: Is it carcinogenic? According to Appendix Tables E referenced sources (Waste Stream 192), the following are carcinogenic:

Cadmium	Anticipated carcinogen
Chromium	Known carcinogen
Benz(a)anthracene	Anticipated carcinogen
Benzene	Known carcinogen
Benz(a)pyrene	Anticipated carcinogen
PCB	Anticipated carcinogen

Each was given an "A" weighting factor level. Once a substance receives an "A" weighting factor level, no further information about toxicity needs to be assembled. If the constituent is not known to be carcinogenic, questions are asked about the aquatic toxicity and mammalian toxicity of the constituent. The reported value on a substance by substance basis is written in the correct column and each is assigned the appropriate level per the toxicity weighting table. For example, $AlCl_3$ has an oral LD_{50} of 3700 mg/kg and Zn (acetate) has 2,460 mg/kg.

Next the toxicity information on a component by component basis is compiled. The toxicity level is assigned. For example, toluene has an aquatic toxicity LC_{50} of 100-10 ppm according to Sax (1983), an oral rat LD_{50} of 5000 mg/kg, no readily available inhalation toxicity data and a dermal toxicity (LD_{50}) of 14,000 mg/kg. These toxicities are D, E, and no category, respectively. Each component is selected for its highest category rating (in order A, B, C, D, and E) and the following formula was applied:

$$EC = \frac{\Sigma A\%}{1} + \frac{\Sigma B\%}{10} + \frac{\Sigma C\%}{100} + \frac{D\%}{1000} + \frac{\Sigma E\%}{10,000}$$

The number for the X axis of the Toxicity Scoring chart is now available. The computation is 0.12.

Then, the weight in kilograms of the entire waste stream is determined. Units are in either yd^3 or gallons. Waste stream 192 is 531,155 gallons. To determine the weight the following steps are followed:

1. Determine density of waste stream:

$$\text{density} = \left(\frac{\%\ \text{Water}}{100}\right) + \left(\frac{\%\ \text{Oils}}{100}\right)(0.9) + \left(\frac{\%\ \text{Solids}}{100}\right)(1.7) + \left(\frac{\%\ \text{Metals}}{100}\right)(5.8)$$

2. To convert from gallons to kilograms:

$$\text{Kilograms} = \frac{(\text{Density}) \times (\text{Gallons})}{0.2641}$$

3. If the waste stream volume was in the unit yd^3, the following formula would have applied:

$$\text{Kilograms} = (\text{density}) \times (\text{cu yd}) \times (764.6)$$

The 531,155 gallons represent 2,092,500 kilograms. Thus, the value for the Y axis is available.

Determination of the Toxicity Score is now possible. One finds the point on the Toxicity Scoring Chart and reads the toxicity rating. For waste stream 192, it is 3 of a possible 0, 1, 2, or 3. Per the rules, no environmental fate score would be developed.

With a Toxicity Score of 1 or 2, one would next determine the environmental fate score on components which fall within boundaries on Toxic Category Table. The environmental fate evaluation focuses on three attributes: persistence, bioaccumulation and solubility. One finds the substance on the persistence list in Section 4 and assigns the level A, B, C, D or E. Bioaccumulation is determined for those substances categorized as everything but "A" under persistence. This is done by locating log P (octanol/water) values and applying the formula:

$$\log P = 5.00 - 0.67 \log S.$$

The category would be determined. Next, one calculates the environmental fate equivalent concentration and determines the environmental fate score by plotting the value on the chart.

Finally, the scores of 3 (toxicity) and - (environmental fate) are combined to determine degree of hazard. The combination means that Stream 192 is a high toxicity hazard stream (see Figure 4-11).

The next activity is to apply the hazard categorization volume tools to Waste Stream 192. Briefly, is there a hazard from disease, fire, leaching agent and biological characteristics? The answers are recorded as output from the classification system. In the case of Waste Stream 192, the decisions follow:

Toxicity Hazard	Moderate
Disease Hazard	None
Fire Hazard	Not known, flash point is not known
Leaching Agent Hazard	Unknown, pH is not known not
Biological Hazard	None

In summary, each of the 30 representative streams was analyzed in a like manner. The chemical profiles developed for the 30 representative streams are shown in Appendix Tables C. The detailed results of screen only implementation is found in Appendix Tables D. The next section provides an overview of these findings.

5.3 Overview of Major Findings

This part of Section 5 provides an overview of the results of the implementation of the screen and of the Degree of Hazard Evaluation. The overview consists of four tables and a brief explanation.

The first table (Table 5-5) shows that the screen triggered 137 yes answers, 100 unknown answers, and 1 no answer. The 137 waste streams with yes answers were usually triggered by the carcinogen question; others were triggered by biological, acute toxicity, flammability and feasibility. One hundred waste streams had chemical profiles whose information was not resolved

sufficiently to gather toxicity and environmental fate information and, therefore, they were scored unknowns. By the rules of the screen methodology, they were sent to the Degree of Hazard Evaluation. Only one, waste stream 99 (latex waste effluent), received no's on all questions and reached the Illinois review box.

TABLE 5-5. SUMMARY OF THE RESULTS OF IMPLEMENTATION OF THE SCREEN

Number of Yes Answers That Trigger Entry to Degree of Hazard	Number of Unknown Answers That Could Trigger Entry to Degree of Hazard	Number of All No Answers That Lead to Illinois Review Box
137	100	1

Table 5-6 provides a summary of names, sizes (volume), and the accumulative toxicity and environmental fate equivalent concentrations and respective scores. In the last column, the combination of the scores is expressed as the overall hazard categorization. The range of volumes is from 1,500 kg for waste streams 107 (mixed solid waste) and 79 extra (oil and water waste) to 162,498,000 kg for waste stream 193 (vacuum filter cake sludge). Equivalent concentrations from accumulative toxicity span several orders of magnitude with a low of 0.0001 for waste stream 244 (waste oil tank #2-6) and a high of 14.43 for waste stream 34 (composite paint sludge). Note that scores of 0, 1, 2 and 3 are represented, meaning that the methodology has the ability to discriminate a range of toxicity matters. Equivalent concentrations for accumulative environmental fate span orders of magnitude with a low of 0.0047 for waste stream 260 (water and oil waste) and a high of 72.72 for waste stream 31 (coal ash).

Table 5-6 also shows the overall hazard categorization, when it was possible to develop it, for the 30 representative waste streams. There were examples of all four hazard categories. Waste stream 44 (diatomaceous filter

TABLE 5-6. SUMMARY OF NAMES, SIZE, ACCUMULATIVE VALUES AND HAZARD CATEGORIZATION FOR THE 30 WASTE STREAMS

Waste Stream No.	genname	Size (Kg)	Accumulative Toxicity: Equivalent Concentration	Accumulative Toxicity: Score	Accumulative Environmental Fate: Equivalent Concentration	Accumulative Environmental Fate: Score	Overall Hazard Categorization
31	Coal ash	39,952,000	0.0047	1	72.72	3	Moderate
34	Composite paint sludge	1,485,700	14.43	3	--	--	High
42	Dewatered lime sludge	2,179,500	1.61	3	--	--	High
44	Diatom earth filter cake	318,500	0.0055	0	--	--	Negligible
67	Foundry sand	1,082,000	0.025	2	0.041	2	Moderate
72	Fuller's earth	12,584,700	0.005	2	5.0	3	High
78	Grease, scum, floatable material	7,571,800	0.017	3	--	--	High
79	Grease/sludge	299,400	0.0067	1	0.021	1	Low
94	Kitchen grease catch basin	10,605,000	0.00034	1	0.60	3	Moderate
107	Mixed solid waste	1,500	0.0021	0	--	--	Negligible
112	Neutralized gasoline cracking	6,716,100	0.057	3	--	--	High
113	Neutralized salts brine solution	7,406,900	0.0017	1	4.70	3	Moderate
117	Oil contaminated materials	2,672,900	0.013	2	48.04	3	High
124	Oily sludge	7,606,100	0.050	2	0.15	2	Moderate
132	Plating treatment sludge	829,600	6.41	3	--	--	High
134	Poly-isocyanurate foam board	160,527,800	--	--	--	--	--
135	Polymer waste water	153,100	0.00043	0	--	--	Negligible
153	Scum from skimmings	590,400	0.0014	0	--	--	Negligible
154	Sewage sludge	28,095,400	0.065	3	--	--	High
192	Used oils	2,092,500	0.12	3	--	--	High

TABLE 5-6 (Continued)

Waste Stream No.	genname	Size (Kg)	Accumulative Toxicity		Accumulative Environmental Fate		Overall Hazard Categorization
			Equivalent Concentration	Score	Equivalent Concentration	Score	
193	Vacuum filter cake sludge	162,498,000	0.54	3	--	--	High
211	Waste oil	290,400	0.37	3	--	--	High
244	Waste oil tank #2-6	1,873,600	0.0001	1	0.013	2	Low
260	Water and oil waste	2,255,100	0.0031	1	0.0047	1	Low
51extra	Foundry sand	63,900	1.6	2	4.4	3	High
59extra	Incinerator ash	536,500	0.0015	0	--	--	Negligible
79extra	Metal hydroxide sludge	1,500	0.12	0	--	--	Negligible
98extra	Oil and water waste	91,900	--	--	--	--	--
151extra	Paint sludge	3,300	0.2	0	--	--	Negligible
330extra	Wastewater treatment sludge	721,100	--	--	--	--	--

cake), 107 (mixed solid waste), 135 (Polymer waste water) and 4 others were of negligible hazard. By contrast, waste stream 34 (composite paint sludge), 132 (plating treatment sludge), and 192 (used oils) and 9 others received a high hazard. There were 5 streams with moderate hazard and 3 with low risk. Another 3 had inadequate information to develop the scores.

Results of the Degree of Hazard Evaluation are provided in Table 5-7 on a waste stream by waste stream basis for the 30 representative streams. Each follows the format:

Waste Stream No.:
GenName:
ProName:
Volume:
Composition:
Toxicity Hazard:
Disease Hazard:
Fire Hazard:
Leaching Agent Hazard:
Biological Characteristics Hazard:

Each of the 30 presentations is in itself a summary and one should study each directly in anticipation of having the information matched to disposal options.

Table 5-8 shows the disposition of the waste streams examined in this study. Details for screening results are available in the Appendix. The original 264 waste streams and the 26 new ones are listed in the left-hand column. The next column shows the 58 waste streams that were eliminated because of duplicate/near duplicate status. Next, the results of the screen are summarized into which streams received yes, unknown and no answers. The last two columns show which waste streams were further analyzed in the Degree of Hazard Evaluation for the "proof of concept" work. The table serves to summarize the scope and direction of the implementation of the methodology.

TABLE 5-7. SUMMARY OF FINDINGS ON A WASTE STREAM BY WASTE STREAM BASIS

Profile	Facts and Answers	
WASTE STREAM NO.	31	
Genname:	Coal Ash	
Proname:	Coal Fired Boilers	
Volume:	9,009 yd^3 (39,952,000 Kg)	
Composition:	Solids	100
Toxicity Hazard:	Moderate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 11.3	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	34	
Genname:	Composite Paint Sludge	
Proname:	Drum Cleaning Operation	
Volume:	834 yd^3 (1,485,700 Kg)	
Composition:	Organic Pigments and Oil	51.4
	Water	21.4
	Inorganic Pigments and Salts	11.9
	Lead	7.6
	$Ca(OH)_2$	5.0
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 11.3	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	42	
Genname:	Dewatered Lime Sludge	
Proname:	Electrogalvinizing Cold Rolled	
Volume:	1310 yd^3 (2,179,500 Kg)	
Composition:	Water	75.5
	Lime Sludge	15.0
	Zinc	5.6
	Inorganic Salts	3.2
	Chromium	0.4
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	None, pH is 9.3	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	44	
Genname:	Diatomaceous Earth Filter Cake	
Proname:	Oil Additive Refining	
Volume:	245 gal (318,500 Kg)	
Composition:	Diatomaceous Earth	90.0
	Lubricating Oil	9.0
	Impurities/Dirt/Etc	1.0
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 11.1	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	67	
Genname:	Foundry Sand	
Proname:	Gray Iron Foundry	
Volume:	832 yd^3 (1,082,000 Kg)	
Composition:	Foundry Sand	98.6
	Cupola Sludge	0.9
	Cupola Dust	0.5
Toxicity Hazard:	Moderate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 10.0	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	72	
Genname:	Fuller's Earth	
Proname:	Filter Fuller's Earth	
Volume:	8640 yd^3 (12,584,700 Kg)	
Composition:	Bentonite	95.0
	$Ca(OH)_2$	5.0
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Unknown, no pH data	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	78	
Genname:	Grease, Scum, Floatable Material	
Proname:	Primary Settling	
Volume:	6460 yd^3 (7,571,800 Kg)	
Composition:	Water	51.8
	Greases, Oils, and Fats	43.5
	Ca, Na, Salts	4.7
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Unknown, pH is not known	
Biological Characteristics Hazard:	High; grease, oil and fats at 43.5%	
WASTE STREAM NO.	79	
Genname:	Grease/Sludge	
Proname:	Bakery Waste	
Volume:	72,000 gal (299,400 kg)	
Composition:	Water	73.1
	Bakery Solids	15.5
	Oil, Grease	11.4
Toxicity Hazard:	Low	
Disease Hazard:	None	
Fire Hazard:	High, flashpoint is 185, oil, grease at 11.4%	
Leaching Agent Hazard:	Moderate, pH is 3.5	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	94	
Genname:	Kitchen Grease Catch Basin	
Proname:	Kitchen Catch Basins	
Volume:	619,900 gal (10,605,000 Kg)	
Composition:	Water	93.1
	Grease	6.3
	Ca, Na Salts	0.6
Toxicity Hazard:	Moderate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 212	
Leaching Agent Hazard:	None, pH is 7.4	
Biological Characteristics Hazard:	High, grease at 6.3%	
WASTE STREAM NO.	107	
Genname:	Mixed Solid Waste	
Proname:	General Cleanup Refuse	
Volume:	75 yd^3 (1,500 Kg)	
Composition:	Inorganic Salts	87.8
	Water	12.2
	Zinc	0.1
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 212	
Leaching Agent Hazard:	None, pH is 8.7	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	112	
Genname:	Neutralized Gasoline Cracking	
Proname:	Petroleum Refinery - FCC Unit	
Volume:	1553 yd^3 (6,716,100 Kg)	
Composition:	Inorganic Salts	92.8
	$Ca(OH)_2$	4.2
	Water	3.0
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 212	
Leaching Agent Hazard:	Moderate, pH is 11.0	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	113	
Genname:	Neutralized Salts Brine Solution	
Proname:	Amines MFG	
Volume:	1,068,702 gal (7,406,900 Kg)	
Composition:	Water	82.7
	Ca, Na Salts	16.9
	NH_4OH	0.4
Toxicity Hazard:	Moderate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 12.0	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	117	
Genname:	Oil Contaminated Solids	
Proname:	General Refinery	
Volume:	708 yd^3 (2,672,900 Kg)	
Composition:	Iron Oxide	35.0
	Silicon Dioxide	26.0
	Iron Sulfate	13.0
	Water, Light Hydrocarbons	13.0
	Aluminum Oxide	9.0
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	None, pH is 4.1	
Biological Characteristics Hazard:	High, light hydrocarbon at 13%	
WASTE STREAM NO.	124	
Genname:	Oily Sludge	
Proname:	Heavy Machinery Manufacture	
Volume:	1,824,500 gal (7,606,100 Kg)	
Composition:	Water	75.0
	Dirt and Fixed Solids	15.0
	Grease and Oil	10.0
Toxicity Hazard:	Moderate	
Disease Hazard:	None	
Fire Hazard:	High, flashpoint 176	
Leaching Agent Hazard:	None, pH is 7.9	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	132	
Genname:	Plating Treatment Sludge	
Proname:	Plating Wastewater Treatment	
Volume:	630 yd^3 (829,600 Kg)	
Composition:	Water	71.8
	Inert Solids	15.3
	Metals	12.9
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Unknown, no pH data	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	134	
Genname:	Poly-Isocyanurate Foam Board	
Proname:	Foam Board Insulation Mfg.	
Volume:	43,937 yd^3 (160,527,800 Kg)	
Composition:	Isocyanurate Foam	75
	Aluminum Foil	15
	Inorganic Fiber	10
Toxicity Hazard:	Unknown, data not adequate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 900	
Leaching Agent Hazard:	Unknown, no pH data	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	135	
Genname:	Polymer Waste Water	
Proname:	Mfg. Chemicals Polymer	
Volume:	40,337 yd^3 (153,100 Kg)	
Composition:	Isocyanurate Foam	97.7
	Synthetic Latex	2.2
	Inorganic Salts	0.1
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	None, pH is 7.4	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	153	
Genname:	Scum From Skimmings	
Proname:	Water Reclamation	
Volume:	770 yd^3 (590,400 Kg)	
Composition:	Water	95.7
	Various Floatables	3.4
	Grit	0.9
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 212	
Leaching Agent Hazard:	None, pH 6.0	
Biological Characteristics Hazard:	High	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
<u>WASTE STREAM NO.</u>	<u>154</u>	
Genname:	Sewage Sludge	
Proname:	Wastewater Treatment Plant	
Volume:	28,175 yd^3 (28,095,400 Kg)	
Composition:	Water	57.6
	Solids	42.4
	Water	57.6
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 11.3	
Biological Characteristics Hazard:	High, organics likely	
<u>WASTE STREAM NO.</u>	<u>192</u>	
Genname:	Used Oils	
Proname:	Waste Oil Pick-up	
Volume:	531,155 gal (2,092,500 Kg)	
Composition:	Used Oils	100.0
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	High, oils at 100%	
Leaching Agent Hazard:	Unknown, no pH data	
Biological Characteristics Hazard:	High, oils at 100%	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	193	
Genname:	Vacuum Filter Cake Sludge	
Proname:	Municipal Sludge	
Volume:	81,456 yd^3 (162,498,000 Kg)	
Composition:	Calcium	13.2
	Domestic Waste	55.9
	Silica Oxides	15.4
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 10.8	
Biological Characteristics Hazard:	High, domestic waste at 55.9%	
WASTE STREAM NO.	211	
Genname:	Waste Oil	
Proname:	Waste Oil	
Volume:	76,000 gal (290,400 Kg)	
Composition:	Water, Dirts	86
	Machine Oil Water Solution	14
	Water	12.6
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None	
Leaching Agent Hazard:	None, pH is 9.1	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	244	
Genname:	Waste Oil Tank #2-6	
Proname:	General Production	
Volume:	506,500 gal (1,873,600 Kg)	
Composition:	Water	75.0
	Oil and Solids	23.5
	Solvents	1.5
Toxicity Hazard:	Low	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Unknown, no pH data	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	260	
Genname:	Water and Oil Waste	
Proname:	Steel Stamping	
Volume:	377,800 gal (2,255,100 Kg)	
Composition:	Water	97.5
	Oil	2.4
	Inorganic Salts	0.1
Toxicity Hazard:	Low	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	Moderate, pH is 13.2	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	51e	
Genname:	Foundry Sand	
Proname:	Molding Process	
Volume:	48 yd^3 (63,900 Kg)	
Composition:	Foundry Sand	93.7
	Copper	1.2
	Resin	1.2
	Nickel	0.1
	Water	3.5
	Lead and Zinc	0.3
Toxicity Hazard:	High	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 212	
Leaching Agent Hazard:	None, pH is 7.9	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	59e	
Genname:	Incinerator Ash	
Proname:	Incinerator	
Volume:	175 yd^3 (536,500 Kg)	
Composition:	Inorganic Salts and Carb	61.2
	Water	37.3
	Ammonium Hydroxide	1.4
	Zinc	0.1
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	None, pH is 9.6	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	79e	
Genname:	Metal Hydroxide Sludge	
Proname:	Electroplating	
Volume:	330 gal (1,500 Kg)	
Composition:	Heavy Metal Hydroxide	1.0
	Heavy Metals	3.0
	Sludge	15.0
	Water	82.0
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	High, flashpoint is 190	
Leaching Agent Hazard:	None, pH is 7.3	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	98e	
Genname:	Oil and Water Waste	
Proname:	Coolant From Machinery	
Volume:	23,000 gal (91,900 Kg)	
Composition:	Water	95.0
	Oil and Grease	4.5
	Inorganic Salts	0.5
Toxicity Hazard:	Unknown, data not adequate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	None, pH is 7.6	
Biological Characteristics Hazard:	None	

TABLE 5-7. (Continued)

Profile	Facts and Answers	
WASTE STREAM NO.	151e	
Genname:	**Paint Sludge**	
Proname:	**Spray Booth Painting**	
Volume:	660 gal (3,300 Kg)	
Composition:	Water	73.9
	Paint, Oils, and Resins	14.8
	Inorganic Salts and Pigm	6.9
	Copper	0.3
	Chromium and Zinc	0.2
	Ethanol, Methanol, But	3.9
Toxicity Hazard:	Negligible	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 200	
Leaching Agent Hazard:	None, pH is 7.5	
Biological Characteristics Hazard:	None	
WASTE STREAM NO.	330e	
Genname:	**Wastewater Treatment Sludge**	
Proname:	**Wastewater Treatment System**	
Volume:	338 yd^3 (721,100 Kg)	
Composition:	Water	62.7
	Calcium Phosphate	30.0
	Calcium Hydroxide	0.5
	Iron Phosphate	5.0
	Lime	2.3
Toxicity Hazard:	Unknown, data not adequate	
Disease Hazard:	None	
Fire Hazard:	None, flashpoint is 212	
Leaching Agent Hazard:	None, pH is 8.9	
Biological Characteristics Hazard:	None	

TABLE 5-8. SUMMARY OF THE DISPOSITION OF THE WASTE STREAMS FOR THE STUDY ON METHODOLOGY AND IMPLEMENTATION

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
1	Activated Sludge		X				
2	Alumin Milling Dust		X				
3	Amoist Asbestos		X				
4	Animal By-Product		X				
5	Animal By-Product Processing Wa		X				
6	Asbestos Containing Paper		X				
7	Auto Paint Line Sludge			X			
8	Backwash Water			X			
9	Bentonite Clay Filter			X			
10	Biological Pond Sludge		X				
11	Black Slag		X				
12	Black Slag		X				
13	Boiler Ash			X			
14	Bou Feed Tank Sludge		X				
15	Brine Water and Solvent Traces		X				
16	Cake Sludge from Municipal Sew		X				
17	Can Washing and Water Sludge		X				
18	Carter Unit Sludge			X			
19	Catalyst Fines		X				
20	Catch Basin Sludge & Water Was		X				
21	Caustic Wash Water		X				
22	Cellulose Wastewater Sludge		X				
23	Chemical Packaging Wastes			X			
24	Chemical Sludge			X			
25	Cinders			X			
26	Cinders	X					
27	Cinders			X			
28	Clarifier Sludge	X					
29	Clarifier Sludge		X				
30	Clay Filter Cake		X				
31	Coal Ash					X	X
32	Coal Ash			X			
33	Coal Tar Sludge		X				
34	Composite Paint Slud (5% Lime)					X	X
35	Contaminated Asphalt Feedstock			X			

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
36	Contaminated Asphalt Feedstock	X					
37	Cosmetic Wash Water Rinse			X			
38	Cranberry and Prune Waste		X				
39	Cranberry and Prune Waste	X					
40	Crank Case Oil	X					
41	Dewatered Aerobically Digester			X			
42	Dewatered Lime Sludge					X	X
43	Dewatered Municipal Sludge			X			
44	Diatom Earth Filter Cake					X	X
45	Diatom Earth Filter Cake	X					
46	Diatomaceous Earth		X				
47	Dirt and Sodium Tripolyphospha			X			
48	Distillation & Evaporation Res		X				
49	Diversion Basin Sludge			X			
50	Draw Off Water	X					
51	Dry Waste Water Treatment Slud			X			
52	Filter Cake & Spent Catalyst			X			
53	Filter Cake Sludge			X			
54	Filter Cake Sludge	X					
55	Filter Cake Sludge		X				
56	Filter Cake Sludge from STP			X			
57	Floor Sweepings & Baghouse Dus			X			
58	Fly Ash			X			
59	Food Process Waste		X				
60	Food Product Waste Various Ani		X				
61	Foundry Sludge		X				
62	Foundry Molding Sand		X				
63	Foundry Sand		X				
64	Foundry Sand		X				
65	Foundry Sand			X			
66	Foundry Sand	X					
67	Foundry Sand					X	X
68	Foundry Sand	X					
69	Foundry Sand		X				
70	Foundry Waste			X			

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
71	Fuel Oil			X			
72	Fuller's Earth					X	X
73	Fuller's Earth Filter Media		X				
74	Fuller's Earth Filter Media	X					
75	Gibberillin Filter Cake		X				
76	Gibberillin Filter Cake			X			
77	Grease & Fats & Water Waste			X			
78	Grease & Scum & Floatable Material					X	X
79	Grease/Sludge					X	X
80	Grease/Sludge	X					
81	Grinding & Machining Fines			X			
82	Grinding Swarf and Oily Air Fi			X			
83	Grinding Swarf and Oily Air Fi	X					
84	Hog Hair and Paunch Residue		X				
85*	Hog Hair and Paunch Residue	X	X				
86	Hot Melt Adhesive Wastes			X			
87	Hot Mill Run Aluminum Liquid		X				
88*	Humin Press Cake	X	X				
89	Human Press Cake			X			
90	Hydraulic Oil		X				
91	Impoundment Basin Sludge			X			
92	Intake Dredge Material			X			
93	Isophthalic Acid Residue			X			
94	Kitchen Grease Catch Basin					X	X
95*	Latex Paint Sludge	X	X				
96	Latex Paint Sludge		X				
97	Latex Wash Water			X			
98	Latex Waste Effluent		X				
99	Latex Waste Effluent		X		X		
100	Lime Slurry		X				
101	Lime Softener Sludge		X				
102	Lime-Alum Softening		X				
103	Lube and Cutting Oils			X			
104	Mayonnaise and Miracle Whip		X				
105	Metal Cleaning Waste Equalizin			X			

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	'Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
106	Metal Hydroxide Sludge		X				
107	Mixed Solid Waste					X	X
108*	Mixed Solid Waste	X		X			
109	Mother Liquor			X			
110	Multi-Stop (Crankcase Oils)			X			
111	Neutralized Acid		X				
112	Neutralized Gasoline Cracking					X	X
113	Neutralized Salts Brine Soluti					X	X
114	Nickel Carbonate		X				
115	Nickel Carbonate	X					
116	Oil Contaminated Materials			X			
117	Oil Contaminated Solids					X	X
118	Oil Contaminated Waste Zone-1			X			
119	Oil Sludge		X				
120	Oil Sludge	X					
121	Oil Waste			X			
122	Oil Waste - UF Concentrate		X				
123	Oil-Sludge/Sediment/Soil			X			
124	Oily Sludge					X	X
125	Oily Waste Water		X				
126	Oily Wastewater from Drum Clng			X			
127	Packaging Waste			X			
128	Paint Screening Sludge		X				
129	Paint Sludge		X				
130	Pencil Pitch Fines		X				
131	Phenolic Resin Coated Core San		X				
132	Plating Treatment Sludge					X	X
133	Poly Resin Coagulum		X				
134	Poly-Isocyanurate Foam Board					X	X
135	Polymer Waste Water					X	X
136	Polymer Waste Water	X					
137	Press Cake		X				
138	Primary Waste Treatment Sludge			X			
139	Processing Waste		X				
140	Processing Waste	X					

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
141	Residual Wax & Water Compoite		X				
142	Residue from K Recovery Process		X				
143	Resin Coated Sand		X				
144	Resin Solids		X				
145	River Mud			X			
146	Salt Cake			X			
147	Salt Slag Cakes		X				
148	Salt Slag Cakes			X			
149**	Sand Filter Sludge						
150	Sand Filter Sludge		X				
151	Scrubber Sludge		X				
152	Scum from Sewage Treatment Process		X				
153	Scum from Skimmings					X	X
154	Sewage Sludge					X	X
155	Shampoo Waste		X				
156	Shampoo Waste	X					
157	Sludge		X				
158	Sludge	X					
159	Sludge		X				
160	Soap & Vegetable Oil Residue		X				
161	Soap & Vegetable Oil Residue		X				
162	Soap & Vegetable Oil Residue		X				
163	Soapy Rinse Water			X			
164	Soapy Rinse Water			X			
165	Soapy Rinse Water	X					
166	Soluble Oil			X			
167	Soluble Oils & Water			X			
168	Soluble Oils & Water	X					
169	SO_2 Removal Sludge		X				
170	SO_2 Scrubber Sludge		X				
171	Spent Bleacing Clay		X				
172	Spent Bleaching Earth	X					
173	Spent Carbon Cake			X			
174	Stamping Coolant Water			X			
175	Synthetic Coolant			X			

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
176	TGU Sulfur		X				
177	TORS Waste Water		X				
178	TORS Waste Water		X				
179	Treated (CA(OH)2 Cold Rinse S		X				
180	Used Buffing Compound		X				
181	Used Lube Oil			X			
182	Used Lube Oil			X			
183*	Used Lube Oil	X		X			
184	Used Lube Oil			X			
185	Used Lube Oil	X					
186	Used Lube Oil			X			
187	Used Lube Oil			X			
188	Used Lube Oil			X			
189	Used Lube Oil			X			
190	Used Motor & Hydraulic Oil			X			
191	Used Oil Roll Oils		X				
192	Used Oils					X	X
193	Vacuum Filter Cake Sludge					X	X
194	Waste Ammonium Chlorine Liquid		X				
195	Waste Coolant Water			X			
196	Waste Copper Solution		X				
197	Waste Copper Solution	X					
198	Waste Crankcase Oil			X			
199	Waste Dug Pot Lining			X			
200	Waste Dug Pot Lining	X					
201	Waste Neutralized Acid Wash WA		X				
202	Waste Oil		X				
203	Waste Oil			X			
204	Waste Oil		X				
205	Waste Oil	X					
206	Waste Oil	X					
207	Waste Oil	X					
208	Waste Oil			X			
209	Waste Oil	X					
210	Waste Oil	X					

TABLE 5-3. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
211	Waste Oil					X	X
212	Waste Oil			X			
213	Waste Oil	X					
214	Waste Oil			X			
215	Waste Oil	X					
216*	Waste Oil	X		X			
217	Waste Oil			X			
218	Waste Oil	X					
219	Waste Oil			X			
220	Waste Oil	X					
221	Waste Oil	X					
222	Waste Oil	X					
223	Waste Oil	X					
224	Waste Oil	X					
225	Waste Oil	X					
226	Waste Oil	X					
227	Waste Oil	X					
228	Waste Oil	X					
229	Waste Oil	X					
230	Waste Oil			X			
231	Waste Oil	X					
232	Waste Oil	X					
233	Waste Oil	X					
234	Waste Oil			X			
235	Waste Oil			X			
236	Waste Oil	X					
237	Waste Oil	X					
238	Waste Oil			X			
239	Waste Oil	X					
240	Waste Oil			X			
241	Waste Oil	X					
242	Waste Oil	X					
243	Waste Oil Crank Case			X			
244	Waste Oil Tank #2-6					X	X
245	Waste Oil Water Dirt & Detergent		X				

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Results of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
246	Waste Oil-Used Motor and Lub			X			
247	Waste Sand			X			
248	Waste Treatment Sludge			X			
249	Waste Wash Water		X				
250	Waste Water		X				
251	Wste Water and Oil		X				
252	Waste Water from Processing		X				
253	Waste Water Runoff		X				
254	Waste Water Treatment Sludge			X			
255	Wastewater Filter Cake Sludge	X					
256	Wastewater Treatment Sludge		X				
257	Wastewater Treatment Sludge		X				
258	Water & Oil		X				
259	Water & Oil Waste			X			
260	Water & Oil Waste					X	X
261	Water and Oils/Ultracentrifu			X			
262	West Equalization Pond Sludge			X			
263	White-Brown Bentone Proc Mud	X					
264	Waste Water Treatment Sludge (Flock)			X			
265	Ammonical Copper Solution		X				
266	Caustic Wash		X				
267	Coolant Machining			X			
268	Cupric Chloride		X				
269	Drum Cleaning Sludge		X				
270	Foundry Sand		X				
271	Incinerator Ash			X			
272	Metal Hydroxide Sludge		X				
273	Metal Hydroxide Sludge			X			
274	Mother Liquor			X			
275	Nickel Plating Bath		X				
276	Oil and Water Waste			X			
277	Paint Sludge		X				
278	Paint Sludge		X				
279	Paint Waste			X			
260	Paint Waste			X			

TABLE 5-8. (Continued)

Waste Stream No.	Genname	Duplicate, Near Duplicate, Inadequate Data	Results of Screen to Degree of Hazard: Yes Answers	Unknown Answers	To Illinois Box No Answers	Pesults of Degree of Hazard: Toxicity Only	Others (See Table 5-7)
281	Pigment Dust			X			
282	Treatment Sludge			X			
283	Waste Water Treatment Sludge		X				
284	Waste Water Treatment Plant Sludge		X				
51e	Foundry Sand		X			X	X
59e	Incinerator Ash		X			X	X
79e	Metal Hydroxide Sludge		X			X	X
98e	Oil and Water Waste			X		X	X
151e	Paint Sludge		X			X	X
320e	Wastewater Treatment Sludge		X			X	X

* Duplicate waste streams were analyzed in screen

** Documentation for Stream 149 is not included in Appendix.

6.0 DISPOSAL OPTIONS AND CHARACTERISTICS

6.1 Description of Treatment/Disposal Methods

The purpose of the task covered in this chapter is to identify and describe appropriate waste management technologies that will be suitable for handling and disposal of special wastes* generated in Illinois. Emphasis was placed on treatment and disposal technologies for the special waste streams identified in Task I and categorized by degree of hazard in Task III. Designation of the management methods for the various wastes focused on demonstrated technologies rather than on highly speculative technologies. Identification of technologies was based on review of the literature, and the knowledge and experience of our staff regarding waste management techniques employed by industrial plants on-site and also these employed off-site by commercial waste management firms. Descriptions of various widely used technologies together with a detailed discussion of their applications to the treatment/disposal of a broad range of Illinois special wastes are provided below.

The broad categories covering the treatment/disposal technologies and waste management strategies considered most suitable for use in the management of a wide variety of special wastes generated in Illinois include:

- Physical/Chemical Treatment
- Land Disposal
- Incineration
- Biological Treatment
- Retrievable Storage
- Waste Reduction/Techniques.

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* The term special waste, according to Illinois ENR (ENR, November 1984), means any "Hazardous Waste", "Industrial Process Waste" or "Pollution Control Waste". "Hazardous Waste" specifically includes RCRA hazardous waste, and some "Industrial Process Waste" and "Pollution Control Waste", which as broadly defined, may be RCRA hazardous wastes. Specifically excluded from the "Industrial Process Waste" category are uncontaminated packaging materials, uncontaminated machinery components, general household waste, landscape waste, and construction or demolition debris. These latter wastes generally would be disposed in a sanitary or municipal landfill.

6.1.1 Physical/Chemical Treatment Methods

Chemical detoxification, neutralization and precipitation are frequently used techniques in the overall management of special (including hazardous) wastes. By themselves, or in conjunction with physical and biological techniques, the chemical treatment methods serve to detoxify some wastes or modify them so that they can be more readily managed or disposed so as to lessen the risk to the environment. Detailed descriptions of the more widely used physical/chemical treatment methods for special wastes are presented below.

6.1.1.1 General. The principal operations that are carried out in a typical inorganic section of an overall treatment facility for handling waste streams are shown in Figure 6-1. These operations, as shown in Figure 6-1, are cyanide oxidation, chromium reduction, acid/alkali neutralization, pH adjustment for heavy metal precipitation, clarification, and sludge dewatering. As shown in Figure 6-1, the cyanide oxidation and chromium reduction steps generally are carried out on segregated waste streams. After treatment, these streams are usually combined with the acid/alkali waste streams for further treatment in the neutralization and pH adjustment tank. The individual treatment operations are described in greater detail below.

6.1.1.2 Chemical Oxidation. Chemical oxidation is a well established process for the treatment of inorganic and organic industrial wastes which include: cyanides, sulfur compounds, phenols, lead, pesticides, aldehydes, and aromatic compounds. Commonly used oxidizing agents for detoxifying wastes include: chlorine gas, sodium hypochlorite, calcium hypochlorite, ozone, air, potassium permanganate, and hydrogen peroxide. The most widely used application of chemical oxidation has been for the destruction of cyanides in wastes generated in electroplating and metal finishing operations.

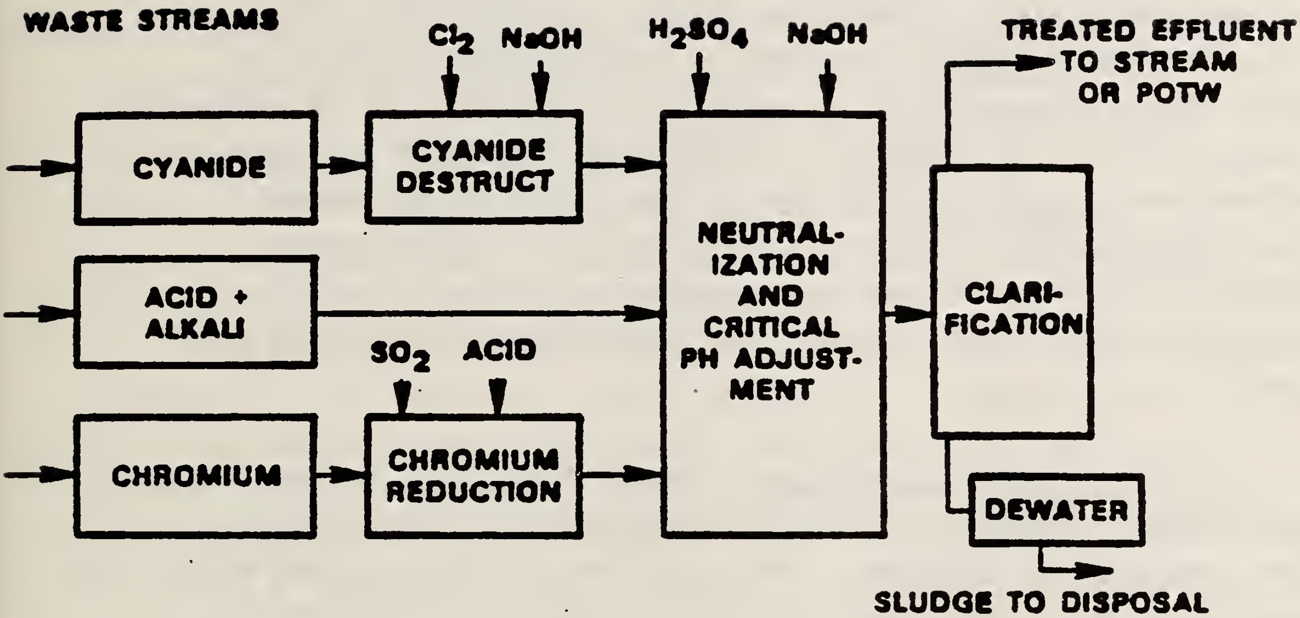

FIGURE 6-1. REPRESENTATIVE INORGANIC TREATMENT FLOW DIAGRAM

Source: Battelle Columbus Division

Destruction of cyanides in electroplating and metal finishing wastes is generally achieved by alkaline chlorination using chlorine and caustic soda (sodium hydroxide) or lime (calcium hydroxide) to produce carbon dioxide and nitrogen (Figure 6-1). Sodium hypochlorite or calcium hypochlorite solutions can be used instead of the gaseous chlorine and caustic soda or lime. Cyanide destruction is generally carried out as a separate operation on agitated wastes (on either a continuous or batch basis) using either a two-tank (or two-compartment tank) or a single-tank system. In the two-tank system, the initial alkaline chlorination treatment to convert the cyanide $(CN)^{-1}$ to cyanate $(CNO)^{-1}$is accomplished in the first tank with the pH of the wastewater at about 10 to 11. The wastewater is then further treated in the second tank with the pH of the wastewater adjusted to about 8.5 to convert cyanate to carbon dioxide and nitrogen. In the singe-tank system, the chlorine or hypochlorite additions are made to the wastewater adjusted to a pH value of about 8.5. Longer overall treatment times are required with the single-tank system.

<u>6.1.1.3 Chemical Reduction</u>. Chemical reduction is employed in some waste treatment operations to lower the valence state and thereby detoxify or modify some hazardous substances. The application of chemical reduction to industrial wastes is well established for dilute waste streams especially those containing hexavalent chromium and other hazardous substances such as lead and mercury. In addition to detoxifying hazardous materials, the process sometimes allows recovery of metals. The most extensive use of chemical reduction has been to convert highly toxic hexavalent chromium in electroplating wastewaters to trivalent chromium which is less hazardous and can be precipitated for removal as discussed below (Figure 6-1).

Although most heavy metal ions are precipitated readily as insoluble hydroxides by pH adjustment in the neutralization-pH adjustment tank, hexavalent chromium does not form a precipitate and must first be reduced to trivalent chromium prior to precipitation. Reduction is generally carried out on either a batch or continuous basis in a tank with agitated waste contents at a pH of 2 to 3 by the addition of gaseous sulfur dioxide (SO_2) or a solution of sodium bisulfate ($NaHSO_3$).

<u>6.1.1.4 Neutralization-Precipitation</u>. Neutralization is a well established technically and economically proven process for the treatment of acidic or alkaline wastes. Neutral-ization, in brief, is a liquid-phase chemical reaction between an acid and an alkali which produces an essentially neutral solution. Precipitation is a chemical process for removing dissolved components from a solution by altering the equilibrium relationships affecting the solubility of the components. The change in equilibrium conditions is usually achieved in waste treatment operations by: (1) changing the solution pH, (2) causing chemical reactions which convert specific components to insoluble products, and (3) changing temperature to decrease solubility of specific components. Almost complete heavy-metal removal by precipitation/clarification operations is required in waste treatment operations to produce aqueous affluents that are suitable for discharge to a stream or to a publicly owned treatment works (POTW).

The products of neutralization are usually water and a salt. If the salt formed has a low solubility in water, much of it will precipitate and form a sludge that will have to be disposed. Acidic wastes are generally neutralized with sodium hydroxide, calcium hydroxide (lime), sodium carbonate, or calcium carbonate (limestone). Alkaline wastes are usually neutralized with sulfuric or hydrochloric acid. Frequently it is possible to judiciously mix or blend acid wastes with alkaline wastes for neutralization, thus saving the costs of purchasing neutralizing agents. Examples of wastes that are treated in the neutralization operation are spent sulfuric or hydrochloric acid pickle liquors from steel cleaning and processing operations, alkaline or acidic cleaning, activating and/or plating solutions from the electroplating and metal finishing industries, spent chemical milling solutions, and acidic/alkaline wastes from the textile, petroleum, pharmaceutical, and other industries.

In facilities where multiple treatment operations are involved, as shown in Figure 6-1, after cyanide oxidation and chromium reduction these two treated streams (when present) are sent to the neutralization/pH adjustment tank or vessel where they join the acid/alkali stream. The individual acid, alkali, or combined acid/alkali streams frequently contain metal-bearing salts from plant operations that did not go to the cyanide or chromate streams.

After neutralization, the trivalent chromium and the other heavy metals from the cyanide and acid/alkali streams are precipitated with the final pH in the tank being between about 8.0 and 9.0 in order to achieve the maximum precipitation of most of the heavy metallic ions present. The pH adjustment and precipitation are usually achieved using sodium hydroxide or lime and sulfuric acid. Settling, clarification and dewatering which are all physical operations, are carried out to produce a treated wastewater effluent suitable for discharge to a POTW or a stream, and a sludge suitable for disposal in an appropriate landfill.

6.1.1.5 Wet Air Oxidation. Wet air oxidation is a process which effectively detoxifies oxidizable organics in dilute solutions by a partial oxidation at moderate temperature (350-650 F) and high pressures (Zimpro, n.d.; Kiang and Metry, 1982).

Basically, wet air oxidation involves liquid-phase oxidation and/or hydrolysis at elevated temperature and pressure. Difficult-to-treat waste streams, which otherwise might be incinerated or deep well injected, can be effectively treated. In practice, pumps brining the wastewater stream into the system at pressures from 300-3000 psig, depending on the particular application. The stream is mixed with compressed air and preheated by the treated effluent before it enters the reactor. In the reactor, molecular oxygen in the air reacts with the oxidizable contaminants in the wastewater to reduce them to relatively simple, essentially nontoxic compounds. The breakdown produced by wet air oxidation of a hypothetical compound is illustrated below:

For example, complex hydrocarbons are initially broken down by hydrolysis into relatively simple hydrocarbons, which are then oxidized to alcohols, aldehydes, acids, and ultimately to carbon dioxide and water. Typical reduction of COD (chemical oxygen demand) values in wastewater by wet air oxidation are about 90 to 95 percent.

Wet air oxidation can also be used effectively as a pretreatment step to destroy toxic components ahead of biological treatment of a waste stream. Thus, wet air oxidation in combination with biological treatment can be used to treat aqueous wastes which are toxic and which are not too amenable to incineration because of large volume flows and low heat values. Zimpro has applied the two-step treatment process of wet air oxidation followed by biological treatment to the full-scale treatment of acrylonitrile wastewaters at several plants in Japan. Wet air oxidation can also be employed to regenerate activated powdered carbon used in biophysical treatment of wastes.

6.1.1.6 Stabilization/Solidification. Stabilization/solidification is a process that is directed at preventing the dissolution of chemicals and the escape of toxic susbtances by chemically stabilizing and/or solidifying contaminated wastes. It usually produces a homogeneous solid mass of low permeability and improved structural integrity. Constituents of stabilized/solidified wastes are much less likely to leach out in a landfill site than untreated wastes, thereby greatly lessening the potential contamination of groundwater and the environment.

The principal industrial wastes treated by this method until very recently have been flue gas cleaning sludges and wastes from nuclear generating facilities. Stabilization/solidification is intended to stabilize the heavy metals in wastes and to facilitate handling and reduce cost of disposal. Excellent detailed coverage of the stabilization/solidification process is provided in the U.S. EPA publication "Guide to the Disposal of Chemically Stabilized and Solidified Waste" (U.S. EPA, 1980).

Stabilization/solidification methods have as their goal the safe ultimate disposal of wastes either via a productive manner or by landfilling. The four main goals of treating hazardous wastes for ultimate disposition are: (1) to improve the handling and physical characteristics of the waste, (2) to decrease the surface area across which transfer or loss of contained

pollutants can occur, (3) to limit the solubility of any pollutants contained in the wastes, and (4) to detoxify contained pollutants. Since these goals can be met in a variety of ways, not all methods attempt to meet all these goals.

The major stabilization/solidification processes can be categorized as follows:

(a) Cement Based Processes - The wastes are slurried in water and then mixed directly with cement. The suspended solid waste particles are incorporated into the rigid matrices of the hardened concrete.

(b) Pozzolanic Processes - The wastes are mixed with lime and a fine-grained siliceous (pozzolanic) material and water to produce a concrete-like solid. The most common pozzolanic materials used in waste treatment are fly ash, ground blast furnace slag, and concrete kiln dust. All of these materials are themselves waste products with little or no commercial value at the present time.

(c) Thermoplastic Techniques - The waste is dried, heated, and dispersed through a heated plastic (e.g., bitumen, paraffin, or polyethylene) matrix. The mixture is then cooled to solidify the mass.

(d) Organic Polymer Techniques - The wastes are initially mixed with a prepolymer (urea formaldehyde) in a batch process, and then a catalyst is thoroughly dispersed in the mixture. Mixing is terminated before the polymer has formed, and the resin-waste mixture is transferred to a waste receptacle. The solid waste particles are trapped in the spongy mass.

(e) Surface Encapsulation Techniques - The wastes are pressed or bonded together and then enclosed in a coating or jacket of inert material (e.g., polyethylene or other organic resins).

(f) Self-Cementing Processes - After calcining a small portion of some industrial wastes, such as flue-gas cleaning or desulfurization sludges which contain large amounts of calcium sulfate and calcium sulfite, they acquire cementing properties and then can be mixed with the bulk of waste sludge to produce a harder plaster-like material with good handling characteristics and low permeability.

(g) Glassification and Production of Synthetic Minerals or Ceramics - With extremely dangerous or radioactive wastes it is possible to combine the waste with silica or fuse the mixture in glass or to form a synthetic silicate mineral. Glasses or crystalline silicates are only very slowly leached by naturally occurring waters, so that these products are generally considered to be safe materials for disposal without secondary containment.

The applicability and compatibility of selected waste categories with different waste solidification/stabilization techniques are presented in Table 6-1 (U.S. EPA, 1980).

The types of wastes most amenable to stabilization/solidification are inorganic materials in aqueous solutions, slurries or sludges which contain appreciable amounts of heavy metals or inorganic salts. Typical wastes processed include: SO_2 scrubber sludges, mine tailings, spent pickle liquors and sludges, spent plating solutions, electroplating and metal finishing wastewater treatment sludges, and sludges from other industrial wastewater treatment operations. Wastes containing more than 10 to 20 percent organic candidates substances (e.g., some oils, solvents, and greases) are generally not good candidates for treatment by stabilization/solidification techniques. The U.S EPA has determined that some stabilized/solidified materials can be handled as nonhazardous wastes under RCRA. For example, U.S. EPA has granted "delisting" to some companies' stabilized/solidified electroplating and metal finishing sludges which allowed them to remove these "treated" wastes from their hazardous waste list. The "delisted" wastes could then be disposed in an approved nonhazardous landfill.

TABLE 6-1 COMPATIBILITY OF SELECTED WASTE CATEGORIES WITH DIFFERENT WASTE SOLIDIFICATION/STABILIZATION TECHNIQUES

Waste component	Treatment Type: Cement based	Lime based	Thermoplastic solidification	Organic polymer (UF)[a]	Surface encapsulation	Self-cementing techniques	Glassification and synthetic mineral formation
Organics:							
1. Organic solvents and oils	Many impede setting, may escape as vapor	Many impede setting, may escape as vapor	Organics may vaporize on heating	May retard set of polymers	Must first be absorbed on solid matrix	Fire danger on heating	Wastes decompose at high temperatures
2. Solid organics (e.g., plastics, resins, tars)	Good—often increases durability	Good—often increases durability	Possible use as binding agent	May retard set of polymers	Compatible—many encapsulation materials are plastic	Fire danger on heating	Wastes decompose at high temperatures
Inorganics:							
1. Acid wastes	Cement will neutralize acids	Compatible	Can be neutralized before incorporation	Compatible	Can be neutralized before incorporation	May be neutralized to form sulfate salts	Can be neutralized and incorporated
2. Oxidizers	Compatible	Compatible	May cause matrix break down, fire	May cause matrix break down	May cause deterioration of encapsulating materials	Compatible if sulfates are present	High temperatures may cause undesirable reactions
3. Sulfates	May retard setting and cause spalling unless special cement is used	Compatible	May dehydrate and rehydrate causing splitting	Compatible	Compatible	Compatible	Compatible in many cases
4. Halides	Easily leached from cement, may retard setting	May retard set, most are easily leached	May dehydrate	Compatible	Compatible	Compatible if sulfates are also present	Compatible in many cases
5. Heavy metals	Compatible	Compatible	Compatible	Acid pH solubilizes metal hydroxides	Compatible	Compatible if sulfates are present	Compatible in many cases
6. Radioactive materials	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible if sulfates are present	Compatible

[a] Urea-Formaldehyde resin.

Source: U.S. EPA, 1980

In summation, stabilization/solidification appears to be an excellent process for the further treatment of a wide variety of wastes, including inorganic residues and ashes from other treatment and incineration operations, to improve their characteristics for safe disposal in hazardous or other landfills.

6.1.1.7 Distillation. Spent halogenated and nonhalogenated organic solvents constitute one of the larger waste stream categories generated by Illinois industries. Major uses of solvents in Illinois are for degreasing and cleaning of metal surfaces preparatory to some manufacturing operations, as components of paints and coatings, and as intermediates in the manufacturing of chemicals, pharmaceuticals, and other products. The technology used most often for recovery and recycling of both halogenated and nonhalogenated organic solvents from waste solvents and solvent sludges is some form of distillation. Distillation is a relatively noncomplex and economic process, and is well suited to the recovery of organic solvents for recycling. With the promulgation of more and more stringent regulations on air pollutant discharges, liquid effluent discharges, and land disposal, along with rising costs of organic chemicals, and the greater attention being given to newer concepts of waste management involving resource recovery, distillation should become more competitive with other methods for organic liquid recovery or disposal.

Distillation entails the separation of the constituents of a liquid mixture by partial vaporization of the mixture and condensation and collection of the vapor, leaving a residue in the still. (Perry and Chilton, 1973, Arthur D. Little, Inc., 1979; Arthur D. Little, Inc., 1976). The more volatile constituents of the original mixture are obtained in increased concentration in the vapor, the less volatile in greater concentration in the liquid residue. The desired product(s) could be in the vapor, the residue, or in both. The discussion below treats simple and fractional distillation as chemical engineering unit operations which are broadly applicable for processing both halogenated and nonhalogenated solvent wastes. Because the

solubility of water in halogenated solvents is characteristically very low and vice-versa, they do not mix, so that steam distillation may be useful alternative to simple or fractional distillation. These three types of distillation are discussed below.

6.1.1.7.1 Simple Distillation. Simple or batch distillation is carried out by heating the liquid mixture in a still pot (steam jacketed vessel) to make it boil. The vapor produced by boiling is driven off, condensed, and collected in an accumulator until the desired concentration in the collected vapor product has been reached. The most volatile component of a mixture tends to distill off first, but unless the other components are nonvolatile or very much less volatile, even the first portion of the condensate will contain some of the material with lower vapor pressure. The proportion of less volatile components in the vapor will increase as distillation continues. Simple distillation is thus most useful as a recovery technique when a volatile material is to be separated from one that is nonvolatile or where there are great differences in volatility. In the event that the residual liquid is the desired product, then the bottoms concentration in the still will be the controlling parameter.

6.1.1.7.2 Fractional Distillation. Where differences in volatility between components are small or moderate, as with the complex mixture of hydrocarbons in crude oil, fractional distillation is more appropriate than simple distillation. Mixtures of water and water soluble organic solvents also can be separated and purified by fractional distillation. In fact, frequently, fractional distillation is the only practical technology available to accomplish such nonhalogenated solvent recovery for recycling.

Fractional distillation is a unit operation in which vapor is continuously and countercurrently contacted in the column with a condensed portion of the vapor. Since all parts are in equilibrium, the equivalent of boiling occurs at all points in the column, but because of the upflow of the vapors of the more volatile component, the temperature decreases slowly from bottom to top of the still. This process produces a greater concentration of

the more volatile component in the vapor at the top, and if the boiling points of the components are not too close, it will be pure. The condensate returned to the top of the column is termed "reflux", and is rich in the more volatile component. In a continuous unit, as pure, high-volatile material is withdrawn slowly at the top and low volatile and nonvolatile material at the bottom, fresh feed is introduced part way up the column. After temperatures stabilize, the still is operated continuously at a rate that preserves the temperature gradient along the column.

A flow diagram of a fractional distillation process is shown in Figure 6-2 (Arthur D. Little, Inc., 1976). The distillation column is the unit in which fractional separation takes place. The column is a tall cylindrical device containing a number of plates or packing materials on which the continuous countercurrent contacts occur. At the bottom of the column is a heated vessel known as the reboiler, in which the liquid phase is vaporized. From the bottom of the column the liquid residue, known as the bottoms, is withdrawn. The bottoms may be a waste to be disposed, or it may simply be the desired highest boiling component of the mixture.

At the top of the column is a condenser in which the vapors, which are highly enriched in the more volatile component, are condensed. A portion of the condensate is allowed to return to the top of the column to supply reflux; the remainder is withdrawn as product. Feed liquid is generally introduced near the middle of the column; the portion of the column above the feed point is known as the rectifying section and the portion below is the stripping section.

6.1.1.7.3 Steam Distillation. Steam distillation is a widely used process for recovering water immiscible, volatile, organic materials from process and waste streams. It can be applied to any waste stream that can be contacted with steam or water without reaction or decomposition. The waste stream can been in the form of liquids, slurries, sludges, and solids. Steam distillation can be considered to be a special form of simple distillation. The term is generally applied to a distillation carried out by the addition of steam directly into the liquid in the still, and its use is limited to those cases in which the solubility of water in the solvent is so low that the two

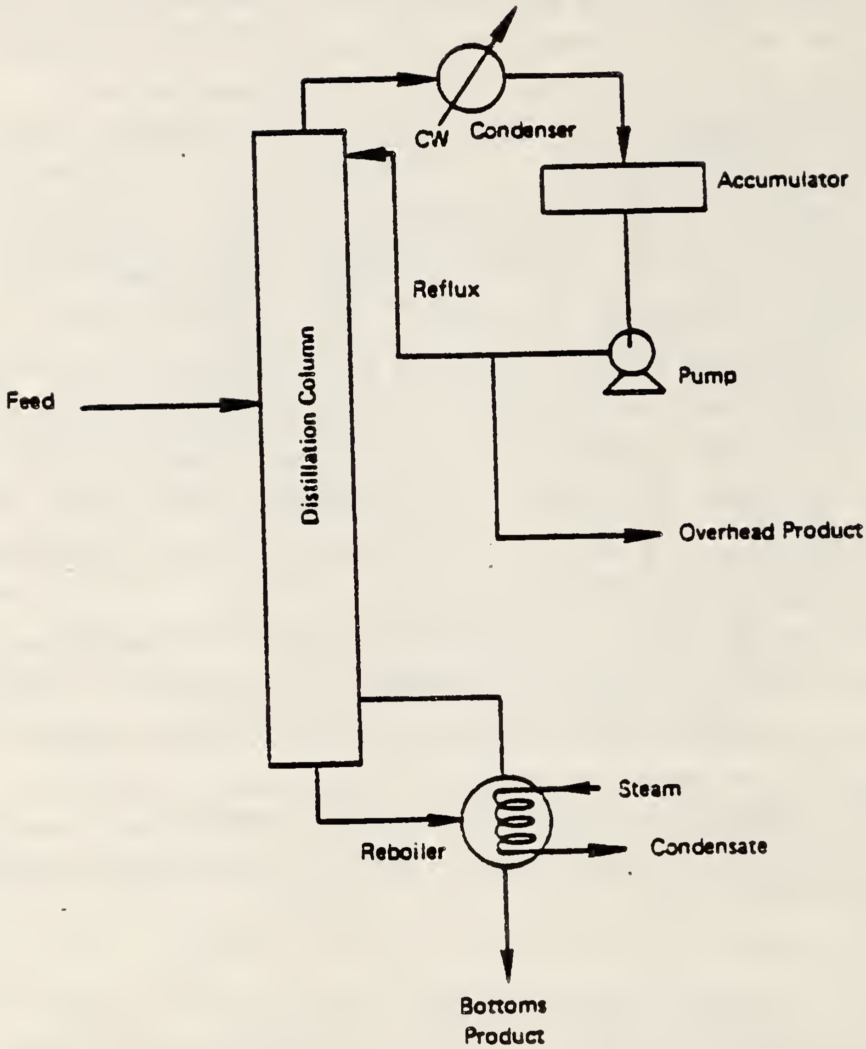

FIGURE 6-2. FRACTIONAL DISTILLATION PROCESS (ARTHUR D. LITTLE, INC., 1976)

liquid phases are immiscible or almost immiscible. The water and the organic solvent phases in the system each contribute to the total vapor pressure of the system, thus permitting distillation at a lower temperature. The condensate is a mixture of the organic material and water; the impurities are left in the still pot. Accordingly, steam distillation is often used for distillation of relatively high boiling organic materials that would decompose if they were distilled directly at atmospheric pressure. Steam distillation is generally applicable to halogenated solvents because most of them are essentially immiscible with water.

Equipment required for steam distillation is relatively simple. A flow diagram of a typical steam distillation system is shown in Figure 6-3 (Arthur D. Little, Inc., 1976). Vaporization takes place in the batch still, which may also have heating coils, in addition to the live steam introduced for the distillation. The vapors are condensed and passed to a gravity separator vessel in which the organic and water phases are allowed to separate. The organic solvent phase is withdrawn, dried, and pumped to storage. The aqueous phase, which may contain traces of solvent, is cleaned up by steam stripping and then discharged as waste, generally to the plant sewer.

Steam distillation is being widely used by contract solvent reclaimers and/or commercial treatment-disposal companies on numerous industrial wastes to recover valuable components or reduce waste volumes. Steam distillation was successfully applied by one waste disposal contractor to the following waste streams: degreasing solvent waste, printing ink waste, paint waste, shoe manufacturing wastes, electronic industry polymer masking waste, and halogenated hydrocarbon wastes (Arthur D. Little, Inc., 1976).

6.1.1.7.4 Disposition of Still Bottoms. Still bottoms, the residues remaining in the still pot after volatile fractions have been vaporized and useful heavier fractions are removed, represent a disposal problem. They contain heavy organics, sludges, and tars; some of which can be toxic. Currently, these distillation residues are generally disposed of in

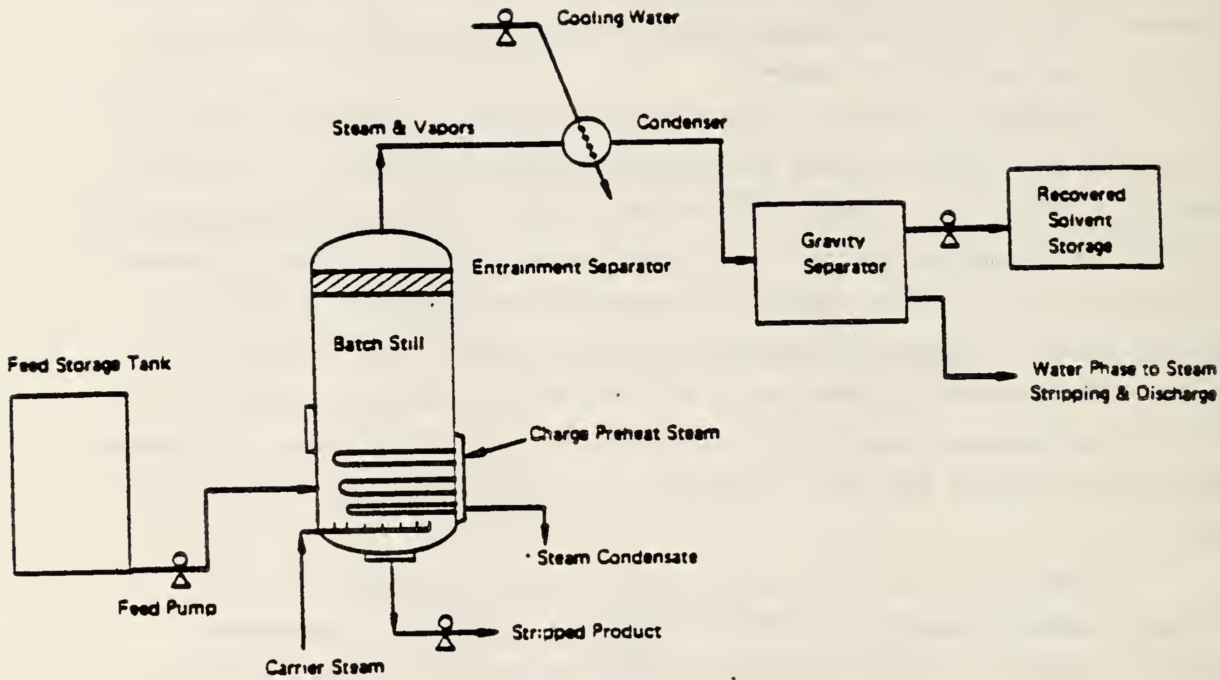

FIGURE 6-3. FLOW DIAGRAM OF A TYPICAL STEAM DISTILLATION SYSTEM (Arthur D. Little, Inc., 1976).

hazardous landfills. However, with the current trend toward limiting the land disposal of hazardous organics, it is expected that since these still bottom residues are mostly organic, they will in the near future be disposed of by incineration.

6.1.2 Land Disposal

Land disposal encompasses landfilling, deep-well injection, and land treatment (land application or land farming). These three types of land disposal are discussed below.

6.1.2.1 Landfilling. Landfilling, either on-site or off-site, has been and still is one of the more widely used methods for the disposal of a wide variety of solid, semi-solid, and liquid wastes, both hazardous and nonhazardous. The wastes may be in bulk form or containerized. However, current U.S. EPA regulations and also Illinois regulations prohibit the landfilling of liquid wastes in hazardous waste landfills. In the near future (i.e., within a year or two), it is expected that the landfilling of even liquids in other than hazardous waste landfills may be eliminated or severely restricted.

For burial of hazardous wastes, a secure or hazardous waste landfill is required to accomplish suitable containment and isolation of wastes. A hazardous waste landfill is specially engineered to avoid direct hydraulic continuity of wastes and waste leachate with surface and subsurface waters by the use of plastic membranes and highly impermeable clay liners. Currently, the use of two synthetic plastic liners or one synthetic plus a highly impermeable (10^{-7} cm/yr or less) clay liner is required under U.S. EPA RCRA regulations for the bottom liner system. Upon closing the landfill, a cover or cap is constructed with low permeability synthetic membrane and/or clay material and with grade slopes to enhance diversion of water and minimize or prevent infiltration of precipitation into landfill cells. Facilities for leachate collection and treatment are essential for handling sludges and other wastes from which hazardous constituents can be leached. Leachate can be

collected by use of suitable series of pipes and a sump at the bottom of the cells, and then pumped to an appropriate container for subsequent transfer to a treatment unit or facility. After appropriate treatment, dewatered solids can be returned to the landfill and the effluent discharged to a POTW or stream.

The composition, volume, and location of specific wastes in the landfill cells are recorded and mapped. Care is taken to segregate wastes to prevent potentially dangerous interactions. Continual surveillance and monitoring of the landfill site, including regular analyses of ground and surface waters for changes in background levels, are required during and subsequent to the landfill's active life.

Because of its "storage-type" method of handling wastes and the short- and long-term potential risk of leachate contaminating groundwater, efforts are under way in Illinois, California, North Carolina, and other states (legislatively and otherwise) to promote more permanent ways of dealing with certain hazardous wastes and using land disposal only as the last resort, primarily for residuals from hazardous waste treatment processes.

Currently, secure landfilling is the most widely used technology for the disposal of F006 (wastewater treatment sludges from electroplating operations) and a large variety of other hazardous wastes. The F006 sludge is a large volume waste generated by the many captive and job shops that carry out electroplating and other metal finishing operations in Illinois. The F006 sludge, consisting of heavy metal hydroxides, can be considered representative of heavy metal hydroxide wastes generated in other industries by neutralization and precipitation operations and of some EP toxic wastes such as D005, D006, D007, D008, and D011.

The new sanitary or municipal landfills that are currently being designed and approved for handling most commercial and municipal wastes have many features of secure or hazardous landfills in that they may have synthetic membrane or highly impervious clay (e.g., 10^{-5} to 10^{-7} cm/yr permeability) liners and in many instances provide for leachate collection and treatment or removal and require perhaps less extensive monitoring than a hazardous waste landfill. They are engineered to prevent infiltration and rain run-in from surrounding areas, etc. Compared to what has frequently been accepted as a "sanitary" landfill in the past, a modern sanitary landfill differs from a secure landfill more by degree than in kind.

As indicated above, the hazardous or secure landfill incorporates features that are designed to provide the greatest degree of protection to the environment from contamination by the buried wastes. An industrial waste landfill, into which many of the special wastes other than RCRA hazardous wastes might be placed, can be considered to be intermediate between the hazardous waste landfill and the sanitary/municipal landfill in the degree of protection that it provides to the environment. For example, a clay liner might suffice in a given design rather than a synthetic membrane. Also, an industrial "monofill" for a specific type of large volume wastes (e.g., coal fly ash) might require fewer security and containment features than a secure hazardous waste landfill, or a landfill which accepts many different kinds of waste. Again, the differences in design between an "industrial" landfill vis-a-vis a secure hazardous waste landfill may be more in degree than in kind. As compared to land disposal in the past, much greater attention is now being paid to proper geology and soil in siting and to containment and prevention of contamination of ground and surface waters.

Generally in the past, most hazardous landfills have been designed so that the landfill foundations are about 20 to 50 or more feet below ground level. However, in the last few years the concept of having an above ground or "mound" landfill (i.e., foundation at or above ground level) has been introduced. The advantages of the above ground landfill are purportedly easier assessability at some future date to the landfill wastes, gravity-type leachate detection and collection, and less likelihood of groundwater contamination.

6.1.2.1. Deep-Well Injection. Deep-well injection involves the emplacement by pumping of certain types of dilute liquid hazardous wastes at high pressures into openings in underground rock formations a few hundred to ten thousand feet or more beneath the earth's surface (Smith, 1979; U.S. EPA, 1977; Amstutz, 1980; OTA, 1983; and Anonymous, 1984). To prevent plugging of the injection well and equipment, wastes are usually pretreated and/or filtered to remove solids. The solids or sludges that result from pretreatment/filtration are generally disposed of in a hazardous waste

landfill. Deep-well injection is attractive because of its relatively low-cost and low-energy requirements. For many wastes, it is environmentally acceptable under the proper geologic conditions. There are several sites in Illinois with one or more deep-wells for waste injection.

Successful deep-well injection requires that there be compatibility of the waste liquids with materials of construction, formation fluids, and the formation itself. In some instances, dissolved waste constituents will react with the formation fluids to produce precipitates that could eventually plug the formation and reduce the disposal zone capacity. Accordingly, waste constituents that are objectionable must be removed or neutralized through chemical treatment, filtration, or other liquid/solid separation techniques. The solids or sludges that arise from the pretreatment operations are periodically disposed of in suitable landfills.

Typical wastes disposed by deep-well injection include inorganic substances such as: acids, alkalis, pickle liquor, chromates, nitrates, phosphates, cyanides, and sulfites, and many organics such as: halogenated and nonhalogenated solvents, phenols, cresylic acid, toluene, formaldehyde, ethylbenzenes, acrylonitrile production wastes, chlorinated hydrocarbons, and organic solutions with high biological or chemical oxygen demand. Some of the principal users of deep-well injection are in the following industries: petroleum refining, petrochemical, steel, chemical, pharmaceutical, auto manufacturing, airlines, fertilizer, food, glass, metal plating, minerals, paper, textile, and miscellaneous manufacturing.

Wastes to be deep-well disposed are injected into sand, sandstone, or limestone formations which will be able to contain and isolate the wastes. These zones are about 500 to 10,000 feet or more beneath the earth's surface and lie between layers of impermeable rock, clay, or shale, with most of the wells falling in the 2,000 to 6,000 ft depth range. The impermeable layers keep the wastes from migrating upward to contaminate groundwater. Injection pressures may range from values less than a hundred to values as high as several thousand kg/sq cm depending on well depth and the nature of the substrate into which the wastes are injected.

Deep-well injection can carry some adverse environmental consequences in that it can contaminate subsurface resources, fresh water aquifers, and surface waters. It also might trigger seismic activity in earthquake-prone regions. These environmental consequences can be prevented or minimized by proper siting of deep wells, proper designing and construction of well casings, and employing good operating procedures and constant monitoring activities.

According to U.S. EPA data, deep-well injection is the most widely used method (volumewise) for hazardous waste disposal in the United States. According to a Chemical Week article, U.S. EPA estimates that domestic industries pumped 12.5 billion gallons of hazardous waste into 194 active deep wells in 1983 alone (Anonymous, 1984). However, based on a survey done by Westat, Inc., for U.S. EPA, it was estimated that 3.6 billion gallons of wastes were injected in the U.S. in 1981 (OTA, 1983). Information about the hazardous characteristics of these latter wastes was not available. Irrespective of the accuracy of these two annual waste volume figures, it is readily apparent that deep-well injection has been, is, and probably will continue to be used for disposal of very large volumes of hazardous wastes. However, in October 1984, Congress inserted a tough amendment in RCRA renewal legislation to ban land disposal (including deep-well injection) of certain hazardous wastes. Under the new RCRA amendment, Congress has ordered U.S. EPA to make of study of deep-well injection within 45 months of enactment of the bill to determine whether the technique is environmentally risky and whether restraints or a ban on its use should be instituted. While it does not appear that deep-well injection will be banned soon, a growing number of chemical firms and other generators are looking at other disposal alternatives to reduce their dependence on this technology.

6.1.2.3 Land Treatment. Land treatment (which has also been called land farming, land spreading, sludge farming or land application) is the controlled application of wastes onto or into the aerobic surface soil horizon, accompanied by continued monitoring and management, in order to change the chemical, physical, and biological state of the waste by biological degradation and chemical reactions as part of the waste's overall disposal

(U.S. EPA, SW-874, 1980; California Gov. Office, 1981, Ross and Phung, 1980; U.S. EPA, EPA-600/2-78-140a, 1978). In the land treatment operation, the waste is initially applied on top of soil to a depth of about 1 to 6 inches or injected about 4 to 6 inches beneath the soil surface. After application, it is generally allowed to dry for several days. The waste is then mixed (e.g., by plowing or diking) with the soil to aerate the mass and expose the waste to the microorganisms naturally occurring in the soil. The soil/waste mass is then periodically remixed to increase the oxygen supply and to maintain the aerobic conditions needed by the microorganisms to effectively biodegrade the wastes. Generally, from time to time, nutrients and limestone are added to the soil/waste mass to promote biological activity. Land treatment is viable only when soil characteristics, site geology, waste characteristics, climate and other environmental conditions permit. The land treatment site should also be fairly level and diked to prevent erosion and runoff, and to keep the soil moist. The important processes that contribute to waste degradation and waste volume reduction include microbial degradation, chemical and photochemical degradation, evaporation, and volatilization.

Land treatment is suitable for wastes containing mainly organic materials which are biodegradable. A listing of industries producing wastes that are amenable to land treatment is shown in Table 6-2 (U.S. EPA, EPA-600/2-78-140a, 1978). As shown in the table these wastes are primarily from petroleum refinery, food processing, paper and allied products, textile finishing, pharmaceutical, and tannery industries. Typical wastes include biosludges, tank bottoms, separator sludges, emulsion solids, and cooling water sludges. The suitability of any specific waste for land treatment depends on many characteristics which include: pH, BOD (biological oxygen demand), organic content, heavy metal concentration, soluble salt concentrations, odor, flammability, and volatility. The land treatment of oily wastes from the petroleum industry is probably the best known and most widely used application of this technique to industrial waste management. Some advantages claimed for land treatment include: low energy requirement for waste disposal, and the ability to make repeat applications of wastes safely at frequent intervals.

TABLE 6-2. INDUSTRIES PRODUCING WASTES AMENABLE TO LAND TREATMENT[a]

Food and kindred products
Textile finishing
Wood preserving
Paper and allied products
Organic fibers (noncellulosic)
Drugs and pharmaceuticals
Soap and detergents
Organic chemicals
Petroleum refining
Leather tanning and finishing

[a] Source: U.S. EPA, EPA-600/2-78-140a, 1980

The principal environmental concerns related to land treatment are: overloading soil with waste constituents, buildup of metal concentrations in the soil, plant uptake of heavy metals, emanation of odors, and runoff of underexposed wastes from the site. In general, these and other potential environmental concerns can be controlled by the use of good operating techniques and effective nurturing programs. Thus, even though land treatment is an attractive waste management method for some oily wastes and organic sludges, the method is not suitable for most hazardous wastes and generally is not acceptable for highly persistent toxic wastes or wastes containing significant amounts of volative organics and heavy metals.

6.1.3 Incineration

6.1.3.1 Introduction. Incineration is one of the more widely used methods in the treatment and disposition of hazardous and nonhazardous process wastes from industry. Incineration is generally used for the treatment of combustible solids, semisolids, sludges, and concentrated liquid wastes arising from processing and manufacturing operations in organic chemical, electroplating and metal finishing, paint, coating, textile, pharmaceutical, petroleum, and other industries.

Incineration is expected to grow in use in the management of hazardous wastes generated in Illinois and elsewhere because of its desirable characteristics of achieving marked volume reductions, detoxification, and its applicability for treatment of a wide range of organic and other combustible wastes. Incinerators achieve essentially complete combustion of wastes by a combination of high temperature, dwell time, and sufficient mixing in the combustion zone. Properly executed, incineration generally can accomplish safe destruction of primarily organic hazardous and nonhazardous wastes, permanently reducing large volumes of waste materials to nontoxic gaseous emissions and small amounts of ash and other residues. Incineration can frequently provide an optimum, permanent solution to hazardous waste management with minimal long-term ecological burden. In some instances, incineration can provide energy resource recovery if the heat generated can be used for the production of steam, which in turn can be used for heating, generation of electricity, or some other purpose.

In the case of RCRA hazardous wastes, the regulatory requirements for closure and postclosure (such as the need for long-term monitoring, testing, and possible treatment) and financial responsibility for incineration facilities will be less of a problem than for other hazardous waste management alternatives, such as landfilling and land treatment (land farming). This feature is expected to have a significant impact on increasing the use of incineration as opposed to landfilling and other hazardous waste management technologies involving hard-to-predict and expensive long-term environmental and financial responsibilities. The use of different incineration systems for the combustion of various types of wastes is discussed below.

6.1.3.2 Description of Incineration Units. The six main types of incinerators that are expected to be involved in the burning of Illinois' special wastes are:

- Liquid Injection
- Rotary Kiln
- Multiple Hearth
- Fluidized Bed
- Cement Kiln
- Industrial Boilers.

These six incineration systems along with their capabilities for burning various types of waste are discussed below (OTS, 1983; TRW, 1979; Scurlock et al., 1975; and TRW, 1977; California Gov. Off., 1981). Of the six incineration systems, the liquid injection and the rotary kiln systems are the most widely used for combustion of wastes.

6.1.3.2.1 Liquid Injection Incineration. Liquid injection incineration can be used to dispose of almost all combustible liquid wastes that can be pumped. A liquid injection system consists of a refractory-lined combustion chamber and a series of atomizing nozzles. Liquid injection incinerators are generally either vertical or horizontal units. Wastes to be burned are usually blended in mixing tanks prior to atomization to improve either their pumpability or their combustibility. The wastes are then atomized through nozzles to increase the rate of vaporization and are then

burned in suspension. Normal combustion temperatures can vary widely and range from about 1200 to 3000 F, with a typical temperature being about 1700 F. Residence times also vary and can range from less then 0.5 seconds to more than 1 second.

A typical vertical-fired liquid incinerator system is shown in Figure 6-4. It can be operated at temperatures of 1600 to 3000 F and features a short start-up period which permits noncontinuous operation. During start-up, an auxiliary burner is used to heat the chamber to the desired temperature. The waste is then fed into the waste air entrainment section and then through the combustion chamber. Additional heated pressurized air is injected near the top of the chamber to create an afterburner effect.

Typical wastes which have been burned in liquid injection units include: separator sludges, oily wastes, detergent sludges, digester sludges, skimmer refuse, cutting oils, coolants, phenols, wine wastes, vegetable oils, soap and detergent cleaners, animal oils and rendering fats, lube oils, spent solvents, soluble oils, polyester paint, PVC paint, thinners, still and reactor bottoms, polymers, cheese wastes, resins, dyes, and inks. Liquid injection units are not recommended for burning heavy metals wastes, high-moisture content wastes, or materials with high inorganic content. Liquid injection incinerators are widely used at industrial locations and also at commercial treatment/disposal facilities.

6.1.3.2.2 Rotary Kiln Incineration. Rotary kiln incineration is generally applicable to the disposal of combustible waste materials in any form (e.g., solids, liquids, slurries, and gases) and represents proven and extensively used technology. The rotary kiln is a cylindrical, horizontal, refractory-lined shell which is mounted at a slight incline. Rotation of the shell causes mixing of the waste with the combustion air, thus improving combustion efficiency. The length to diameter ratio of the combustion chamber normally varies between 2/1 and 10/1. For example, some large units are about 40 feet x 16 feet in size. Speed of rotation is normally in the range of 1 to 5 feet per minute. Combustion temperatures vary according to the characteristics of the material being incinerated but normally range from 1500 to 3000 F. Residence times vary from several seconds to hours, depending on the waste; gaseous and liquid wastes have the shorter dwell times.

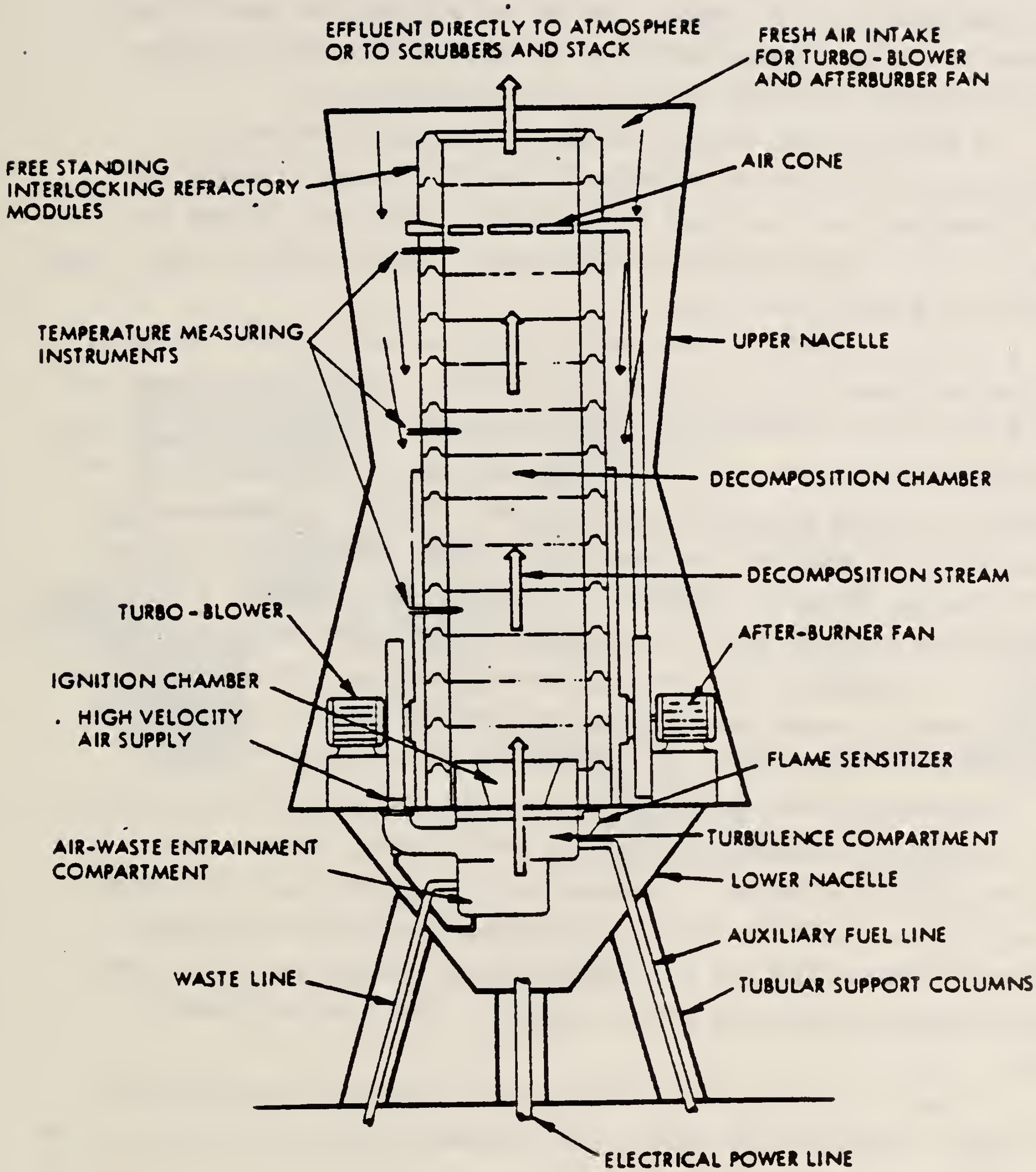

Figure 6-4. Typical Vertically-Fired Liquid Waste Incinerator (TRW, 1979)

Most rotary kiln installations, particularly those handling hazardous wastes, are equipped with wet scrubber emission controls. Heat recovery equipment is also common. The latter may take the form of heat exchangers to preheat combustion air or of waste heat boilers for steam generation (usually practical only in large installations).

A typical large (65 million Btu/hr) industrial rotary kiln incineration facility, which is located at the Dow Chemical Company at Midland, Michigan, is illustrated in Figure 6-5. This unit is used for disposal of solid waste chemicals, solid refuse, liquid residues, paper, wood, and other solid and liquid wastes.

In the operation of this rotary kiln, the solid refuse is fed by crane from the dumping pit to the charging hopper. Solid tars in drums are fed into the 13-foot diameter kiln by a hydraulically operated drum and pack feeding mechanism. While solids are being fed, the liquid wastes are fired horizontally into the rotary kiln. The typical rotary kiln temperature is 1500 F. Resulting ash from the combustion process, consisting of slag and metallic objects, is water quenched. The gaseous products enter a secondary combustion chamber which permits sufficient dwell time to assure complete combustion. No secondary fuel or afterburners are used. The emission gases then pass through a water spray chamber for fly ash removal, under a stack damper, and out through a 200-foot stack.

Rotary kiln incinerators have been used to burn a wide variety of wastes including PVC wastes, waste paints and solvents, PCB in waste capacitors, obsolete chemicals, obsolete munitions, phenylamine tar wastes, acrylonitrile manufacturing wastes, and bottoms from solvent reclamation operations. Rotary kilns are not recommended for combustion of heavy metal sludges, inorganic salts, and other wastes with high inorganic material content.

Rotary kilns are in use in many large industrial plants and are widely used in commercial or centralized treatment/disposal facilities in the United States and Europe.

6.1.3.2.3 Multiple Hearth Incineration. The multiple hearth incinerator (commonly called a Herreshoff furnace) is a versatile unit that has been used to dispose of all forms of combustible wastes including sludges, tars, solids, liquids, and gases.

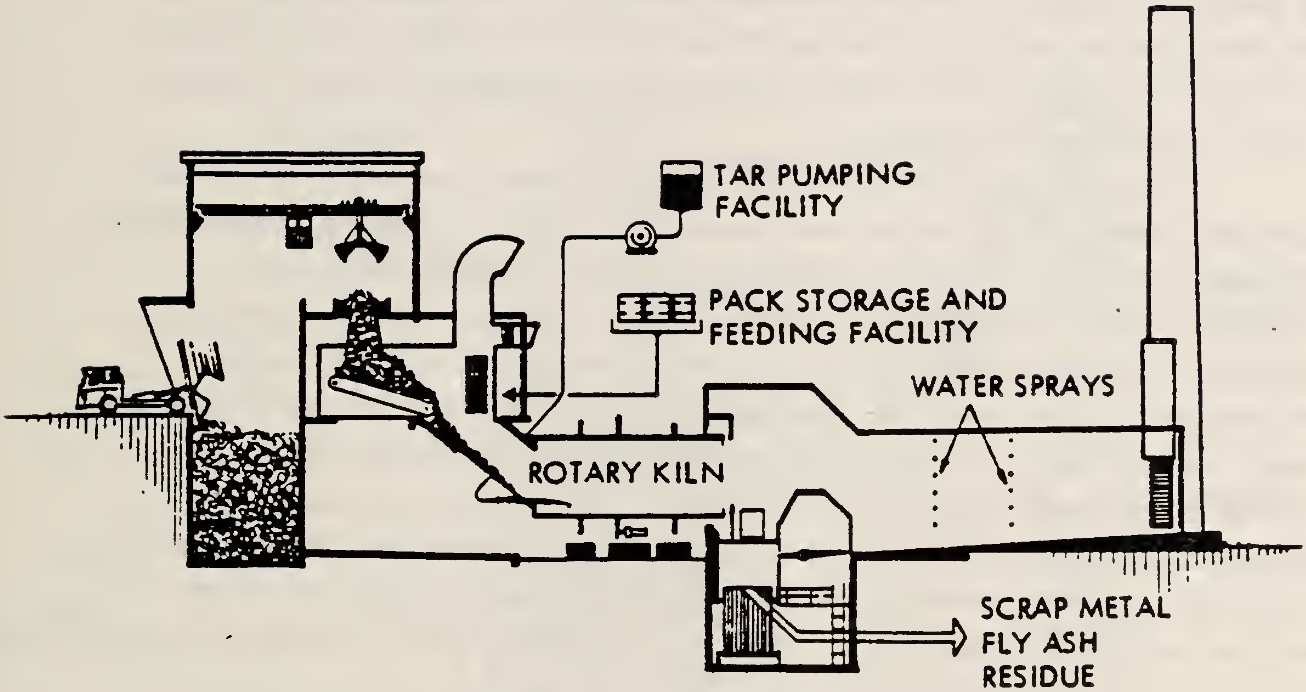

Figure 6-5. Typical Major Industrial Rotary Kiln Incineration Facility (TRW, 1979)

The basic furnace is a refractory-lined circular steel shell with vertically stacked refractory hearths (see Figure 6-6). These incinerators generally range in size from 12 to 75 feet in height and from 6 to 25 feet in diameter. Sludges are normally fed to the top hearth, greases and tars through side ports, and liquid and gaseous wastes through auxiliary nozzles. The rotating central shaft is equipped with horizontal plows which push the waste material across the face of the hearth to the drop holes. The wastes fall through the holes to the next hearth, and so on, until residual ash falls to the furnace floor. Air and combustion products flow countercurrently to the feed from the bottom to the top of the combustion chamber. Gases normally exit at 500 to 1000 F and in most cases pass through emission control devices prior to atmospheric discharge.

Multiple hearth incinerators have been used since the 1930's to burn municipal sewage sludge and various industrial sludges. Although used mostly for sewage sludge incineration, these units have also been used to burn chemical sludges, pharmaceutical wastes, reactor bottoms from PVC production, and other nonsewage wastes. The principal advantages of multiple hearth incinerators include very long residence times for solids (i.e., up to several hours) and sludges, high-fuel efficiency because of the tiered hearth, and ability to handle a wide variety of sludges. Since there are usually hot and cold spots throughout the units which may prevent thorough combustion, the units have high-maintenance costs, and they are not well suited for wastes with ash which fuses into large, rock-like structures.

6.1.3.2.4 Fluidized-Bed Incineration. Fluidized-bed incinerators are quite versatile, being usable for the disposal of liquid, gaseous, and solid combustible wastes. The use of the fluidized-bed process for waste disposal is relatively new, having been in commercial use for only about the last 20 years. The basic fluidized-bed incinerator consists of a refractory-lined cylindrical vessel containing a bed of inert granular material (such as sand) or a perforated metal plate (see Figure 6-7). Blower-driven air enters at the bottom and proceeds vertically through the bed, agitating or "fluidizing" it and causing it to behave in a nature similar to a dense liquid mass. Wastes are injected pneumatically, mechanically, or by gravity into the bed. Rapid and relatively uniform mixing of wastes and bed material occurs.

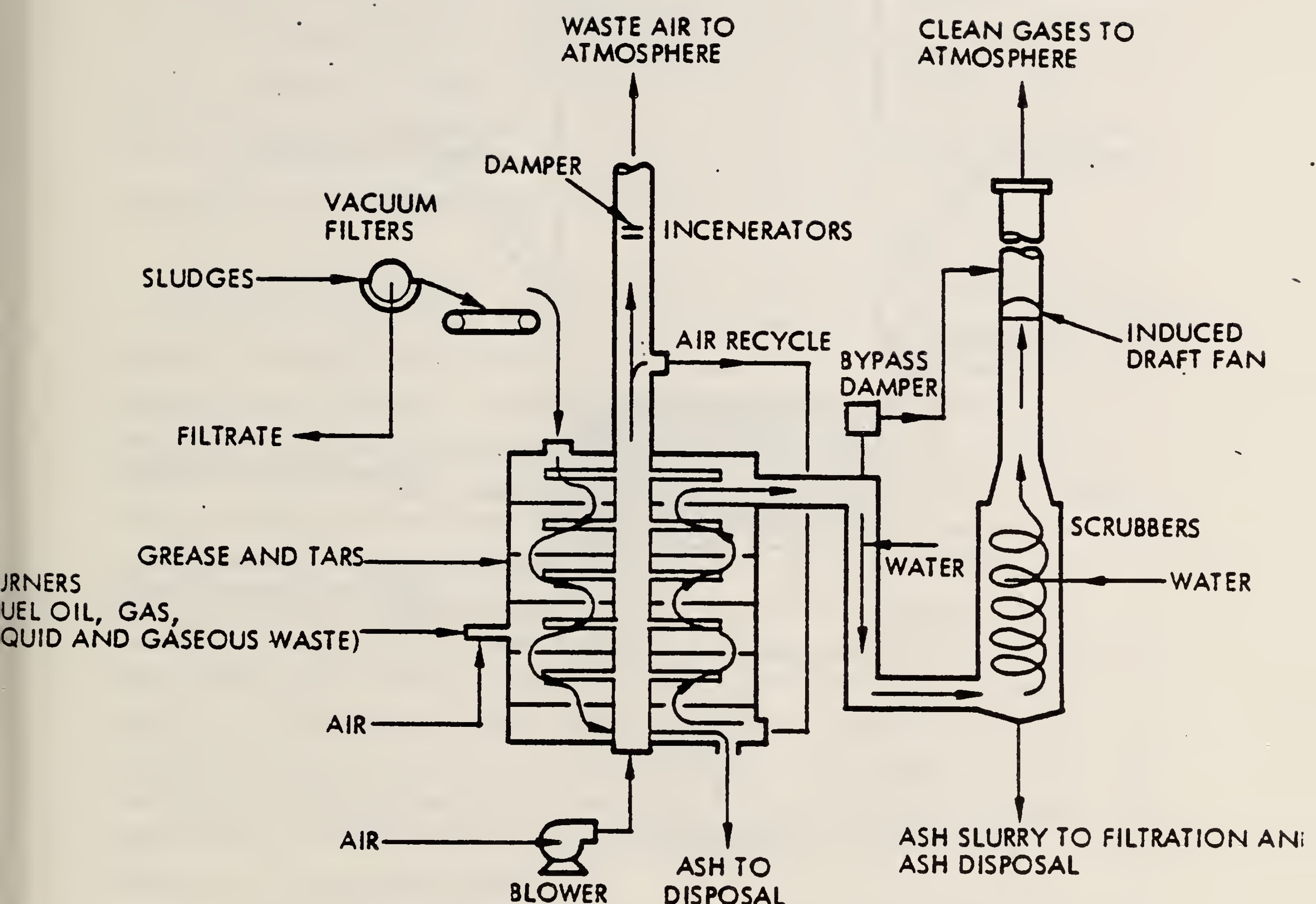

Figure 6-6. Multiple Hearth Incineration System (TRW, 1979).

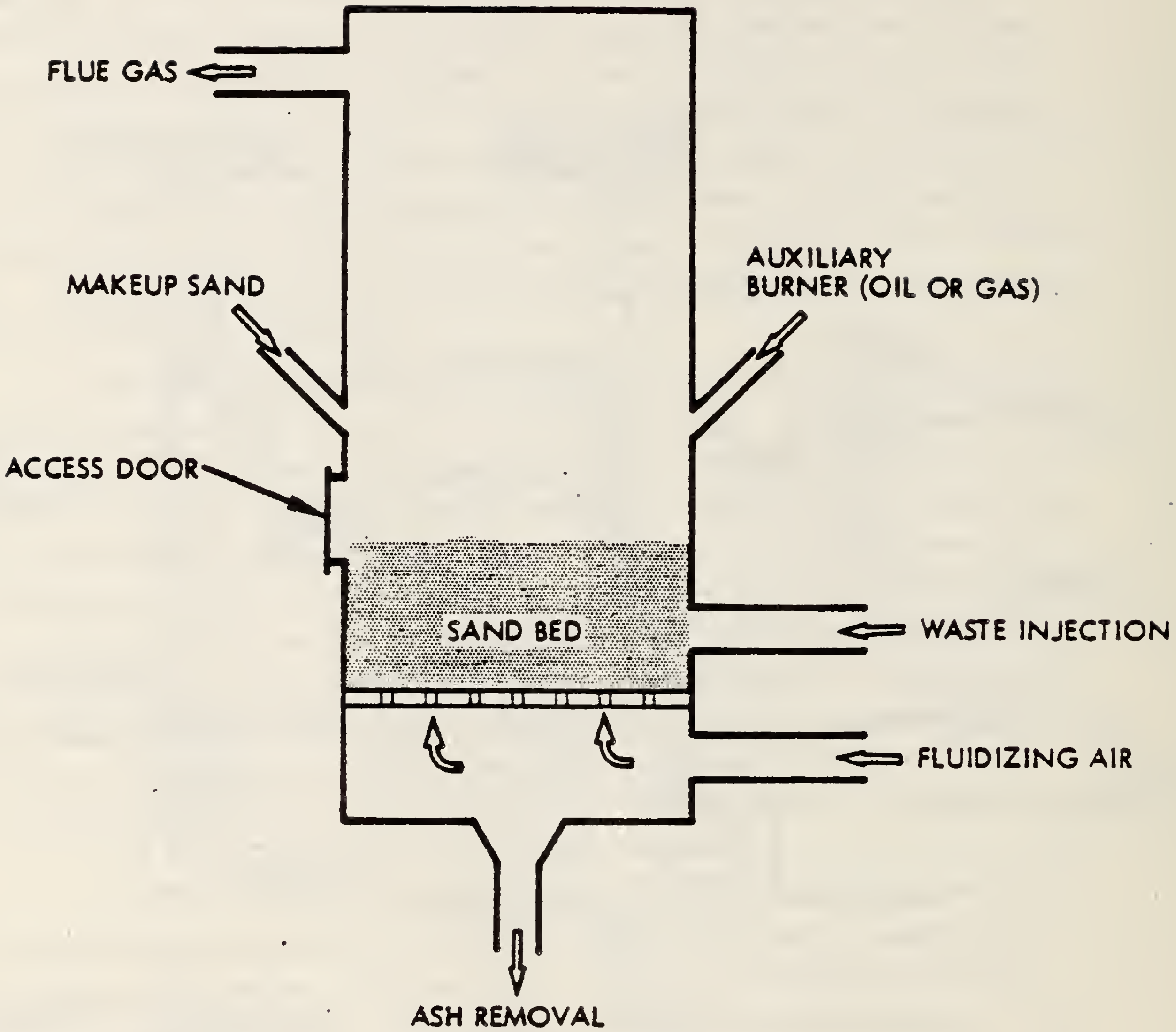

Figure 6-7. Schematic of a Fluidized-Bed Combustor (TRW, 1979)

In the combustion process, heat transfer occurs between the bed materials and the injected waste materials. Typical bed temperatures are in the range of 1400 to 1600 F. Residence times are in seconds for gases and liquids; times are longer for solids. Heat from combustion is transferred back to the bed material. Solid materials remain in the bed until they have become small and light enough to be carried off with the flue gas as a particulate. Collected ash is generally land disposed.

Fluidized beds are primarily used to dispose of sludges from municipal wastewater treatment plants, oil refineries, and pulp and paper mills. Although there is only limited data related to their use as hazardous waste incinerators, it is generally believed that this approach to waste incineration offers significant potential for the future.

6.1.3.2.5 Cement Kiln Incineration. Cement kiln incineration can be considered a special type of rotary kiln incineration in which organic wastes are cofired with the base fuel in a cement kiln. Cement manufacturing generally entails exposing limestone and other additives to temperatures between 2600 to 3000 F in a rotary kiln fired with a fossil fuel. The end product of this operation is clinker, which is a major constituent of cement. Since the combustion conditions in cement kilns are much more severe than those present in many waste incinerators, cement kilns are considered a promising disposal option for many organic wastes. The thorough mixing conditions, long residence times, and high temperatures in the cement kiln make possible more complete combustion of even difficult-to-burn organic wastes. The alkaline environment in the kiln makes it especially suitable for incinerating chlorinated wastes because of its ability to neutralize the hydrochloric acid produced during combustion. Most of the ash and nonvolatile heavy metals are incorporated in the clinker produced in the kiln and eventually in the cement product.

Currently, wastes such as spent solvents, still bottoms from solvent reclaiming operations, and waste oils are being purchased (or taken in at a low or very low cost to the waste generator) by cement companies for burning on a continuous basis in their kilns. The advantages of using kilns are that in addition to destroying the wastes, the energy value of the wastes are

reclaimed and waste disposal costs are low. There are also some disadvantages. For example, when burning chlorinated and other wastes in kilns, there is increased production of particulates so that more extensive air pollution control devices must be employed. In addition, greater monitoring of operating conditions must be employed when burning wastes than when the kiln is burning it customary fuels.

Considerable research is being conducted by U.S. EPA to better assess the waste burning capabilities of cement kilns, since they provide a large readily available capacity for burning a large variety of wastes. It is believed that greater use of cement kilns for waste burning will occur in the near future.

6.1.3.2.6 Boiler Incineration. Combustible wastes with sufficient heating value can be coincinerated with a primary fuel in some types of boilers. Thus, by coincineration the energy value of the waste serves to produce steam while at the same time the waste is disposed by burning. Some advantages of boiler incineration are: (1) relatively low capital expenditures if present boilers can be adequately modified to accept wastes, and (2) wastes used onsite as fuel do not require further treatment or disposal. It is difficult to assess the amount of wastes burned in boilers since many chemicals, which could be considered hazardous if they appeared in waste streams, are looked upon as fuels. This is because they have been historically looked upon as fuels and have only rarely been disposed of as wastes. Disadvantages of boiler incineration include: (a) the introduction of some wastes into boilers designed to burn other fuels may be damaging to the boiler components, (b) the difficulty of successfully burning combined wastes with different heat values, and (c) the probable need to put in new or additional stack cleanup devices capable of dealing with unburned organic or other troublesome particulates from the waste streams.

Considerable research is under way to better establish the performance capabilities of boilers for burning various wastes and also on methods to improve such performance.

TABLE 6-3. COMPARISON OF VARIOUS INCINERATION TECHNOLOGIES FOR WASTE BURNING[(A)]

Advantages of design features	Disadvantages of design features	Status for hazardous waste treatment
Currently available incinerator designs:		
Liquid injection incineration:		
Can be designed to burn a wide range of pumpable waste. Often used in conjunction with other incinerator systems as a secondary afterburner for combustion of volatilized constituents. Hot refractory minimizes cool boundary layer at walls. HCl recovery possible.	Limited to destruction of pumpable waste (viscosity of less than 10,000 SSI). Usually designed to burn specific waste streams. Smaller units sometimes have problems with clogging of injection nozzle.	Estimated that 219 liquid injection incinerators are in service, making this the most widely used incinerator design.
Rotary kilns:		
Can accommodate great variety of waste feeds: solids, sludges, liquids, some bulk waste contained in fiber drums. Rotation of combustion chamber enhances mixing of waste by exposing fresh surfaces for oxidation.	Rotary kilns are expensive. Economy of scale means regional locations, thus, waste must be hauled, increasing spill risks.	Estimated that 42 rotary kilns are in service under interim status. Rotary kiln design is often centerpiece of integrated commercial treatment facilities. First noninterim RCRA permit for a rotary kiln incinerator (IT Corp.) is currently under review.
Cement kilns:		
Attractive for destruction of harder-to-burn waste, due to very high residence times, good mixing, and high temperatures. Alkaline environment neutralizes chlorine.	Burning of chlorinated waste limited by operating requirements, and appears to increase particulate generation. Could require retrofitting of pollution control equipment and of instrumentation for monitoring to bring existing facilities to comparable level. Ash may be hazardous residual.	Cement kilns are currently in use for waste destruction, but exact number is unknown. National kiln capacity is estimated at 41.5 million tonnes/yr. Currently mostly nonhalogenated solvents are burned.
Boilers (usually a liquid injection design):		
Energy value recovery, fuel conservation. Availability on sites of waste generators reduces spill risks during hauling.	Cool gas layer at walls result from heat removal. This constrains design to high-efficiency combustion within the flame zone. Nozzle maintenance and waste feed stability can be critical. Where HCl is recovered, high temperatures must be avoided. (High temperatures are good for DRE.) Metal parts corrode where halogenated waste are burned.	Boilers are currently used for waste disposal. Number of boiler facilities is unknown, quantity of wastes combusted has been roughly estimated at between 17.3 to 20 million tonnes/yr.
Applications of currently available designs:		
Multiple hearth:		
Passage of waste onto progressively hotter hearths can provide for long residence times for sludges. Design provides good fuel efficiency. Able to handle wide variety of sludges.	Tiered hearths usually have some relatively cold spots which inhibit even and complete combustion. Opportunity for some gas to short circuit and escape without adequate residence time. Not suitable for waste streams which produce fusible ash when combusted. Units have high maintenance requirements due to moving parts in high-temperature zone.	Technology is available; widely used for coal and municipal waste combustion.
Fluidized-bed incinerators:		
Turbulence of bed enhances uniform heat transfer and combustion of waste. Mass of bed is large relative to the mass of injected waste.	Limited capacity in service. Large economy of scale.	Estimated that nine fluidized-bed incinerators are in service. Catalytic bed may be developed.

(a) Source: OTA, 1983.

6.1.3.2.7 Comparison of Incineration Technologies. A comparison of the advantages and disadvantages of the different incineration technologies, discussed above, in the burning of various wastes is presented in Table 6-3. The status of the particular technology for hazardous waste treatment is also covered.

6.1.4 Biological Treatment

Biological treatment is a generalized term that is applied to a set of processes which employ living microorganisms to decompose organic wastes into either water, carbon dioxide, or into simpler organics such as aldehydes and acids (Arthur D. Little, Inc., 1976; California Gov. Office, 1981; OTA, 1983). Biological treatment processes involve placing a waste stream in contact with a mixture of microorganisms, so that the organic compounds in the waste stream are decomposed. Typically, the microorganisms used in the process are present in the influent waste stream. The process optimizes the microbial environment, so that natural degradation is enhanced. Methods for optimizing biological degradation include: controlling the dissolved oxygen level, adding nutrients, increasing the concentration of microorganisms, and slowly increasing influent waste concentrations so that an acclimated microbial population develops within the process.

Biological treatment is applicable to aqueous waste streams with organic contaminants. The organics may be either solvent or solute in the influent waste stream to be amenable to biodegradation. Water is essential in the waste stream. The microorganisms rely on enzymes to catalyze organic decomposition reactions, and the enzymes require water to remain active. In aerobic biological treatment processes, both simple and complex organics can eventually be decomposed to carbon dioxide and water. Oxygen is essential to the decomposition of long chain and aromatic hydrocarbons. In anaerobic biological treatment processes, only simple organics such as carbohydrates, proteins, alcohols, and acids can be decomposed.

Biological treatment processes generally do not alter or destroy inorganics. In fact, concentrations of soluble inorganics should be kept low so that enzymatic activity is not inhibited. Trace concentrations of

inorganics may be partially removed from the liquid waste stream during the biological treatment, because of adsorption onto the microbial cell coating. Typically, microorganisms have a net negative charge and are therefore about to perform cation exchange with metal ions in solution Anionic species, such as chlorides and sulfates, are not affected by biological treatment.

With a properly acclimatized microbial population and good operating conditions, biological treatment is applicable to the processing of selected industrial waste streams. Biological treatment is probably the most cost-effective method for treatment of organic wastes in an aqueous medium. Energy and chemical demands are low compared to other processes; however, land requirements are greater. An overview assessment of the characteristics of seven biological treatment processes and their overall applicability to industrial processing waste streams is shown in Table 6-4 (Arthur D. Little, Inc., 1976). These processes are

- Activated Sludge
- Trickling Filter
- Aerated Lagoon
- Anaerobic Digestion,
- Waste Stabilization Pond
- Composting
- Enzyme Treatment.

These seven biological treatment processes along with their applicability for treating industrial waste streams are discussed below (Arthur D. Little, Inc., 1976 California Gov. Office, 1981; OTS, 1983).

6.1.4.1 Activated Sludge. In the activated sludge process, aqueous organic wastes are decomposed by exposing them to flocculated biological growths which are continuously circulated to provide good contact with the wastes in the presence of air. The process involves an aeration step, followed by solids-liquid separation, with recycle of a portion of the solids

TABLE 6-4. OVERVIEW OF BIOLOGICAL TREATMENT PROCESSES(a)

Biological Process	Principal Microbial Population	Optimum Temperature	Range in pH	% Solids in Waste Stream	Average Retention Time	Organic Decomposed	Estimated BOD Upper Limits Effectively Handled	Effluent	Residue	Energy Demand As % Total Cost	Chemical Demand As % Total Cost	Total Cost/ 1,000 Gallons
Enzyme Treatment	None	Mesophilic	1.5-9.5 Varies per enzyme	< 50%	Nil	All can be decomposed by a series of enzymes	No limit	CO_2 and water if complete treatment, otherwise intermediate decomposition products	None	< 10%	< 10%	Prohibitive production and immobilization cost
Activated Sludge Treatment	Aerobic Heterotrophic Bacteria	Mesophilic	6-8	< 1%	< 1 Day	All but oil, grease and halogenated aromatics, nitrogen compound	<10,000 mg/l	CO_2 and water, 5%-15% influent BOD remains	Biomass sludge	> 10%	> 10%	< $5
Trickling Filter	Aerobic Heterotrophic Bacteria	Mesophilic	6-8	< 1%	< 1 Day	All but oil, grease and halogenated aromatics, nitrogen compound	< 5,000 mg/l	CO_2 and water, 10-20% influent BOD remains	Biomass sludge	< 5%	> 10%	< $3
Aerated Lagoon	Aerobic Heterotrophic Bacteria and Facultative Anaerobic Heterotrophic Bacteria	Mesophilic	6-8	< 1%	2-7 days	All but oil, grease and halogenated aromatics, nitrogen compound	< 5,000 mg/l	CO_2 and water, 10-30% influent BOD remains	Biomass sludge	> 10%	> 10%	< $3
Waste Stabilization Pond	Aerobic Heterotrophic Bacteria and Autotrophic Algae	Mesophilic	6-8	<0.1%	3-6 Months	Mostly carbohydrates proteins, organic acids and alcohols	<100 mg/l	CO_2 and water, 10-40% influent BOD remains	None	< 5%	< 5%	< $2
Anaerobic Digestion	Obligate Anaerobic Heterotrophic Bacteria	Thermophilic	6.4-7.5	< 10%	2 Weeks	Mostly carbohydrates proteins, organic acids and alcohols	Not applicable	Mixed liquor of biomass and interstitial water; 40-50% influent volatile sludge solids remain	"Stabilized sludge	< 5%	< 5%	< $15
Composting	Aerobic Heterotrophic Bacteria and Facultative Anaerobic Heterotrophic Bacteria and Fungi	Mesophilic and Thermophilic	5-8.5	< 50%	3-6 Months	All organics, phosphorus compounds and nitrogen compounds	No limit	Leachate with soluble organics	None	< 5%	> 10%	< $30

Source: Arthur D. Little, Inc. 1976.

back into the aeration tank to maintain high concentrations of microorganisms. The basic system has an open tank for the mixture of the active biomass with influent wastewater and air followed by a clarifier. Bacteria in activated sludge systems serve to perform hydrolysis and oxidation reactions. Activated sludge treatment is extensively used in industry, and is probably the most cost-effective method of destroying organics present in an aqueous waste stream. It is a safe and reliable process which is relatively uncomplicated to operate and relatively inexpensive. The activated sludge process has been applied extensively to treat wastewater from municipal sewage plants, canneries, paper and pulp mills, refineries, breweries, and steel, textile, petrochemical, pharmaceutical, and timber processing plants. However, the process is not considered acceptable for decomposing halogenated hydrocarbons and other organic compounds which break down at extremely slow rates. The activated sludge process is considered to be environmentally sound as it employs natural microbial metabolic processes and does not require the addition of chemicals.

6.1.4.2 Trickling Filter. In the trickling filter process, wastes are sprayed through the air to absorb oxygen and then allowed to trickle through a bed of rock or synthetic media coated with a slime or microbial growth. The process involves the use of open tanks or towers to house the filter packing, followed by effluent clarifiers. Recycle pumps may be used to recirculate filter effluent. A rotating spray dosing system feeds influent wastewater to the filter surface. The primarily metabolic processes are aerobic, and the microbial population is similar to the activated sludge population. However, because to the relatively short contact time, the percentage removal of organics is not as great. The trickling filter process is a proven technology for the decomposition of organics in waste streams with less than 1 percent suspended solids. Trickling filters have been extensively used in sewage treatment and in treatment of refinery wastewaters containing oil, phenol, and sulfide. They are applicable to the same industrial waste streams as the activated sludge process, including cannery, pharmaceutical, and petrochemical wastes. BOD removal efficiencies ranges from 50 to

85 percent. Because the trickling filter process generally is not efficient enough to use as a sole method of biodegradation, the process is frequently used in industry to accept wastewater loading variations and provide a relatively uniform effluent for treatment by other biological processes, such as activated sludge.

6.1.4.3 Aerated Lagoons. The aerated lagoon biological treatment process decomposes organics in wastewater containing less than 1 percent solids, employing essentially the same microbial reactions as activated sludge. Usually the lagoon is a large earthen basin with sloping sides and about 6-17 feet deep. Because wastewaters in aerated lagoons are generally not as well mixed as those in activated sludge basins, a low level of suspended solids is maintained. If mixing and aeration are not complete, a portion of the solids settles to the bottom and undergoes anaerobic microbial decomposition. Retention times are slightly longer than for activated sludge; and where anaerobic decomposition is encouraged, the time is even longer. The aerated lagoon process differs from the activated sludge process in that it does not have a sludge recycle system for continuous circulation of microorganisms, and microbial strains do not acclimatize to the same extent. BOD removal efficiencies range from 60 to 90 percent. The process is not as attractive for industrial waste treatment as the activated sludge process; removal efficiencies are not as high and the process is less flexible in maintaining effluent limitations under varied influent loading conditions. The aerated lagoon process has been successfully used for petrochemical, textile, pulp and paper mill, cannery, and oil refinery wastewaters.

6.1.4.4 Anaerobic Digestion. Anaerobic digestion is used for the degradation of relatively simple organic matter in an air free environment. The organic sludges and biomass sludges from primary clarification and biological treatment are processed to reduce their volume and improve stability. The anaerobic digestive system uses two types of bacteria, i.e., acid forming and methane forming. The methane forming bacteria depend on the acid forming bacteria for their substance. An end product of anaerobic digestion is the combustible gas methane. In the conventional anaerobic digestion process, the waste stream is fed into the middle zone of a closed

tank with no agitating mechanism. The solids are digested by the organisms, gas rises, bringing scum to the surface, and the gas is collected from the roof of the tank. Usually this gas is used to maintain the temperature of the installation and sometimes to heat other parts of the plant. The digested sludge settles to the bottom of the tank after 30 to 60 days. There is only a small volume of digested sludge, which is stable and inert and generally can be disposed of for land reclamation or landfilling. The process typically treats sludges containing 5-7 percent solids; the sludge generally is reduced in volume by 40-60 percent. The anaerobic digester bacteria are sensitive to pH, temperature, and the composition of the waste, but usually with time the system will achieve its own balance. Modifications have been made for some installations, usually involving agitation or heating, which shortens the process to several days to two weeks.

For efficient anaerobic digestion to occur, it is necessary for steady state environmental conditions to be maintained in order to keep the two types of bacteria in balance. Because of this delicate balance, anaerobic digestion generally is considered not suitable for treatment of most industrial processing sludges. Oil, fat and grease in sludges are also troublesome to the process.

6.1.4.5 Waste Stabilization Ponds. Waste stabilization ponds utilize natural biodegradation reactions in wastewaters containing less than 0.1 percent solids with low concentrations of organics. Waste stabilization ponds are large shallow basins where wind action provides aeration and a mixed autotrophic and heterotropic microbial population provides decomposition of organics over a long retention time (i.e., days to months). Warm climates speed the decomposition process. Deep ponds, (e.g., more than 4 feet deep), may promote anaerobic decomposition of settled sludge. The process requires large land acreage, which is the principal cost item, since energy and chemical requirements are insignificant.

The waste stabilization pond process is more sensitive to concentrations of inorganics and suspended solids than any of the other biological treatments discussed in this report. It is suitable for industrial wastes only where preliminary treatment has removed most contaminants and

final effluent polishing is needed before discharge to a receiving water. Toxic inorganic materials must be removed before waste stabilization ponding because of the system's high sensitivity to inhibitors.

Waste stabilization ponds have been widely used for sanitary sewage and dilute industrial wastes, mostly to provide final effluent polishing. Industries using the method include meat and poultry packing, dairies, iron and steel works, paper and pulp mills, textile mills, oil refineries and petrochemical plants.

6.1.4.6 Composting. Composting provides a means of achieving aerobic digestion of organic wastes by microorganisms in the presence of their own released heat. It is the only biological treatment process relatively insensitive to toxicants and it encourages adsorption of metals. Composting basically involves piling ground waste in windrows and aerating the piles by periodic turning. All that needs be done is scheduling of spreading and turning with earthmoving equipment, adding some nutrients and alkalis if necessary, and providing for collection of leachate and runoff water to protect groundwater. Complete digestion of most organic wastes take place in three or four months, although refinery wastes or other difficult organics may take up to a year.

Systematic composting has been widely used in Europe, where there is a ready market for composted waste as an organic soil conditioner. Most of the demonstration projects in the United States have closed for lack of a market for humus, but some cities use this cost-effective disposal technique for municipal refuse and give the compost away. Chicago uses the system to dispose of high-strength organic sludges, and several petroleum refineries use it for refinery wastes. It has also been used for cannery solids, pharmaceutical and meat packing sludges.

6.1.4.7 Enzyme Treatment. Enzymes are highly selective chemical catalysts which act on specific molecules. Enzymes catalyze specific reactions and cannot adapt well to the varying composition of typical waste streams. Because of this, enzyme treatment of industrial processing wastes generally is considered impractical. In addition, enzyme production is very expensive.

The selectivity of enzyme action on specific molecules is illustrated by the following examples. The urease enzyme, for example, breaks down urea into carbon dioxide and ammonia. The cellulose enzyme, produced by a stream of fungus, trichoderma viridi, catalyzes the hydrolysis of cellulose to glucose. And lastly, a hydrolase enzyme, derived from yeast, has been shown to oxidize phenol to carbon dioxide and water. Thus, the enzyme treatment process could be attractive if recovery of a specific compound is intended, provided the waste composition and compound concentration remain fairly constant.

As of 1976, there were no known full-scale applications of enzyme treatment processes in hazardous waste management. There are commercial applications in meat tenderizing, de-hairing of hides prior to tanning, cheese-making, pharmaceutical manufacture, and detergent production. However, enzymes are believed to offer little potential in general waste management.

6.1.5 Retrievable Storage

Retrievable storage refers to a secure system for the long-term storage of wastes prior to recycling, treatment, destruction, or ultimate disposal (California Gov. Office, 1981). Such a system provides an alternative for those wastes which have been determined to be unsuitable for landfilling, but for which there do not currently exist economical treatment technologies. The use of such retrievable storage systems is advocated by California and other state legislatures especially for hazardous wastes that cannot be treated, stabilized or destroyed to the extent which renders them sufficiently low in toxicity so as to not present any significant health or safety hazard.

Desirable characteristics of an acceptable retrievable storage system are:

- The system must provide for the safe storage of the wastes.
- The system must have sufficient capacity to accept large quantities of waste without endangering the equipment or personnel.

- The system must be equipped to allow for the easy removal of the wastes when treatment becomes available.
- The system should comply with all federal (U.S. EPA) and state regulations or standards regarding proper and safe storage of hazardous wastes.

Retrievable storage systems can employ the use of tanks, drums, and for certain nonvolatile wastes, impoundment ponds. Liquid waste impoundment ponds can be considered for use as retrievable storage systems if the pond is properly designed and engineered and has a suitable liner system to adequately isolate it from the land under and adjacent to it. With the growing tendency for U.S. EPA and state legislatures of proposing bans on landfill disposal of selected types of chemicals or wastes, the use retrieval storage systems is expected to become an important waste management option. Areas of particular environmental concern, related to retrievable storage systems, are accidental spills and fires. These and other concerns, related to the storage systems for chemicals in general, will have to be addressed by proper system design and operating standards.

6.1.6 Waste Reduction Techniques

6.1.6.1 Introduction. With the imposition of more stringent regulations, coupled with steadily rising costs of environmentally adequate treatment and disposal of hazardous wastes, there have been increased efforts in industrial and government plants to reduce the amounts of hazardous and other wastes generated (Gurklis, et al., 1983). In-process controls, process modifications, process or product substitutions, and recover/recycling (R/R) techniques are among the more effective and economically attractive methods being employed for reducing the size of the onsite treatment facility and/or the amount of hazardous wastes to be stored, treated, and disposed under RCRA.

Both technological and economic considerations influence the use of process changes and recovery/recycling techniques in a plant for waste reduction. For example, economics is generally the limiting and one of the most important constraints for making modifications to allow for recovery/recycling of a particular waste or waste stream. Given the expenditure of sufficient effort and funds, almost any waste could be

recovered for recycling with available technologies. Economic considerations, involving the implementation of process changes and/or recovery/recycling techniques in plant operations, dictate that these changes or techniques result in increased process efficiency, an actual profit, or at least an avoidance of a treatment and/or disposal cost. Accordingly, implementation of these waste reduction techniques requires that the capital costs involved not be excessive and that an economically viable scale of operation can be achieved. Even when both economic and technical considerations are satisfied, barriers may exist which prevent or hinder adoption of process modifications. These may include unfamiliar processing techniques, quality control problems, inertia, and ignorance of the advantages or benefits arising from process modifications, to cite a few. Both education and economics should increasingly encourage industries to overcome these barriers.

6.1.6.2 Examples of Applications of Waste Reduction Techniques. Some examples of existing or potential uses involving the implementation of process changes and/or recovery/recycling techniques for reducing the amounts of hazardous wastes in Illinois requiring treatment and/or disposal are discussed below (Gurklis, et al., 1983). Many recovery/recycling technologies generally employ modifications of physical/chemical, biological, or incineration technologies to recover or reuse a valuable waste ingredient or by-product that otherwise would be destined for hazardous waste treatment and disposal. Several examples of successful application of waste reduction and/or recovery/recycling techniques follow.

- Distillation of both halogenated and nonhalogenated spent solvents and solvent sludges to recover and recycle or resell reclaimed solvents.
- Recovery of electroplating chemicals from rinsewaters (destined for wastewater treatment) by the use of vacuum evaporation, reverse osmosis, or ion exchange for recycling back to the plating bath; some examples follow:
  (1) Economical recovery of valuable plating chemicals from many plating baths including chromium, nickel, cadmium cyanide, and zinc cyanide has been achieved using vacuum evaporation.

(2) The principal applications of reverse osmosis (RO) systems in electroplating involve mostly recovery of plating chemical from nickel baths and a limited number of acidic zinc, copper and chromium baths.

- Dewatering metal-bearing and other sludges as much as practical because hauling and disposal charges are generally on a weight or volume basis.
- Re-refining waste oils to produce high quality lubricating oils.
- Recovery of hydrochloric acid and iron-oxide (sold for magnetic tape use) values from spent steel mill pickle liquor.
- Utilization of spent pickle liquor (both sulfuric and hydrochloric) for their ferrous sulfate or ferrous chloride values for municipal or industrial wastewater treatment and purification.
- Employment of process substitutions, in which a nonhazardous process solution is substituted for a hazardous solution for making an essentially similar product; two examples follow:

  (1) Vacuum deposition of aluminum coatings on some aircraft parts has been successfully employed as a substitute for a cadmium coating electroplated from a cyanide bath. Such a process substitution results in eliminating the need for cyanide destruction and the subsequent disposal of the cyanide-bearing sludge in a secure landfill.

  (2) Electroplating copper from a copper sulfate rather than a copper cyanide bath eliminates the need to treat a cyanide waste stream.
- Segregation of process wastes, so that potentially hazardous wastes are not mixed with nonhazardous wastes, to cut down on the amounts of wastes to be managed as hazardous waste.

6.1.6.3 Waste Exchange. The use of waste exchanges is another form of waste reduction. The exchange and reuse of waste materials, besides protecting the environment, results in savings by the elimination of the need for treatment and/or disposal together with savings in costs of raw materials

and in the energy to produce the raw materials. Waste exchanges, when successful, do offer a partial solution to some solid and hazardous waste disposal problems which is economical and environmentally attractive.

The types of materials most frequently listed in American waste exchanges and for which successful transfers have been made include the following categories: (U.S. EPA, 1980).

Organic Chemicals and Solvents
Oils, Fats, and Waxes
Textiles, Leather, and Rubber
Wood and Paper Products
Spent Catalysts
Metal Containing Sludges and Slags
Spent Catalysts
Acids
Alkalis
Inorganic Chemicals
Metals
Plastics.

Generally, the most successful transfers have involved "relatively pure" hazardous or industrial waste materials rather than contaminated or mixed wastes. Although the successful exchange of hazardous wastes has been somewhat limited, it does, in some instances, provide a potential avenue for economical and environmentally sound waste management.

6.2 Generalized Assessment of Treatment/Disposal Methods

The generalized waste treatment capabilities of various treatment/disposal (T/D) technologies are summarized in Table 6-5. The capability or applicability of seven waste management technologies or strategies, namely: incineration, hazardous waste landfilling, industrial waste landfilling, physical/chemical treatment, biological (including land

treatment), deep-well injection, and recovery/recycling (R/R), for handling wastes with particular characteristics is presented in the matrix table. The capabilities were designated or rated in four generalized categories; namely:

P - Preferred
A - Acceptable
NAC - Not Acceptable
NAP - Not Applicable.

It should be noted that the designation ratings are of a rather general nature and in many instances more than one rating designation is applied for a particular T/D technology. This is because it is difficult to apply a specific designation when dealing with a generalized characteristic or property of a waste. In many instances, the rating will depend on the physical state of the waste, the concentration of pertinent constituents in the waste, and the specific identity and source of the waste stream.

To better illustrate the general purpose of the waste characteristic versus treatment/disposal technology data presented in Table 6-5, the example of Halogenated Solvent wastes is considered and discussed in Table 6-6.

On the basis of the discussion in Table 6-6, one can see the difficulty of trying to achieve anything but a rather generalized table relating the applicability of generalized treatment/disposal technologies to waste streams whose characteristics are also only available in generalized terms. It is believed that the satisfactory selection of appropriate treatment/disposal option(s) will have to be based on looking closely at particular waste streams and specific compositions and other characteristics of these streams (such as has been done in applying our waste classification system in Section 5). For example, incineration techniques generally would not be applicable to inorganic liquids, solids, or sludges. On the other hand, incineration would generally would be the preferred method for dealing with most organic wastes, especially those not amenable to R/R or biological treatment techniques. Incineration is especially appropriate for treatment/disposal of difficult-to-destroy items such as halogenated organic chemical production residues and sludges, pesticide wastes, and spent solvent sludges.

TABLE 6-5. GENERALIZED WASTE HANDLING CAPABILITIES OF VARIOUS TREATMENT/DISPOSAL TECHNOLOGIES[a]

Capability of Handling Wastes with Characteristics Listed Below	Incineration	Hazardous Waste Landfilling	Industrial Waste Landfilling	Physical/ Chemical Treatment	Biological (Including Land Treatment)	Deep-Well Injection	Recovery/ Recycling
Toxicity-Negligible to High	P or A	P or A	A or NAC	P, A or NAP	A or NAC	P or A	A or NAP
Ignitable	P or A	A or NAC	A or NAC	A or NAP	A or NAC	A or NAC	A or NAP
Flammable	P or A	A	A or NAC	A or NAP	A or NAC	A or NAC	A or NAP
Infections (Disease)	P or A	NAC	NAC	A or NAP	A or NAP	NAP	NAP
Biological	P or A	A	A	A or NAP	P or A	A or NAP	A or NAP
Solvents (Halogenated)	P or A	NAC	NAC	A or NAP	A or NAC	P or A	P, A or NAP
Solvents (Nonhalogenated)	P or A	NAC	NAC	A or NAP	A or NAC	P or A	P, A or NAP
Organics	P or A	A or NAC	A or NAC	A or NAP	P, A or NAP	P, A or NAP	P, A or NAP
Inorganics	NAC or NAP	P or A	P or A	P or A	NAP	P, A or NAP	P, A or NAP
Corrosive (High or Low pH)	P, A or NAC	A or NAC	A or NAC	P or A	NAP	A or NAC	A or NAP
Liquids	P, A or NAP	NAC	A or NAC	A or NAP	A or NAP	P, A or NAP	A or NAP
Solids	P, A or NAP	P or A	A or NAC	A or NAP	A or NAP	NAP	A or NAP
Sludges	P, A or NAP	A or NAC	A or NAC	A or NAP	A or NAP	NAP	A or NAP

(a)Key: P = Preferred
A = Acceptable
NAC = Not Acceptable
NAP = Not Applicable

TABLE 6-6 ILLUSTRATIVE EXAMPLE ON USING T/D TECHNOLOGY/ WASTE CHARACTERISTIC TABLE

Waste Stream Characteristic	Treatment/ Disposal Technology	Waste vs. T/D Designation	Comment
Solvent (Halogenated)	Incineration	P or A	Incineration can be the preferred or acceptable method for disposing of the waste if R/R techniques are not applicable.
Solvent (Halogenated)	Hazardous Waste Landfilling	NAC	Assuming solvent waste is liquid, its disposal in a hazardous waste landfill is not permitted.
Solvent (Halogenated)	Industrial Waste Landfilling	NAC	It is presumed that a landfill with somewhat lower capabilities would not be generally suitable for disposal of halogenated solvent wastes.
Solvent (Halogenated)	Physical/ Chemical Treatment	A or NAP	Whether P/C techniques such as distillation would be applicable for recovery/recycling of solvent values will depend on solvent concentration, solvent identity, and its price, etc.
Solvent (Halogenated)	Biological	A or NAC	Generally, concentrated solvents would be detrimental to most microbial activities. Very dilute concentrations (e.g., <1.0%) of solvents in wastes might be acceptable.
Solvent (Halogenated)	Deep-Well Injection	P, A or NAP	Deep-well injection can be used. It would be a P if R/R were not a viable alternative, and an A even if R/R were borderline or not readily available.

TABLE 6-6 (Continued)

Waste Stream Characteristic	Treatment/ Disposal Technology	Waste vs. T/D Designation	Comment
Solvent (Halogenated)	Recovery/ Recycling	P, A or NAP	Solvent recovery for recycling by distillation or some other technique is a preferred and highly desirable option, providing solvent concentration in the waste is amenable to successful separation techniques, etc., and the economic considerations are favorable. Otherwise, R/R could be an acceptable option or a nonapplicable option for reasons cited above.

6.3 Integration of Treatment/Disposal (T/D) Methods and Degree-of-Hazard Output

The manner in which the data on the capabilities of the various treatment/disposal methods and other waste management strategies, which were presented in the above portion of Section 6, is applied to the degree-of-hazard output to assist in the selection of one or more T/D options is described below.

Waste Streams 192 and 31 were selected to serve as examples to illustrate how the T/D technology selection process works. The following data are available from Section 5 on Waste Stream 192:

WASTE STREAM NO.	192
Genname:	Used Oils
Proname:	Waste Oil Pick-up
Volume:	531,155 gallons (2,092,500 kg)
Composition:	100%
Toxcity Hazard:	High
Disease Hazard	None
Fire Hazard:	High, oils at 100%
Leaching Agent Hazard:	Unknown, no pH data
Biological Characteristics Hazard:	High, oils at 100%.

Using these above data, together with data presented in the TD/waste characteristic matrix (Table 6-5) along with engineering experience and knowledge of TD technology capabilities, one can select one or more T/D options for dealing with the waste. The following are elements involved in the T/D selection process in conjunction with the matrix table:

(a) The waste oil is presumed to be liquid, therefore, it is not permitted to be disposed of in a hazardous waste landfill. Nor is it considered suitable for disposal in an industrial waste landfill because of fire hazard and other considerations.

(b) Because of the high toxicity hazard the waste is not acceptable for disposal by land treatment.

(c) The treatment of the waste oil using the physical/chemical methods as part of the overall recovery/recycling strategy to produce rerefined oil is an available option. Two of the 12 hazardous waste management firms, listed as taking in waste oil, also indicate that they are engaged in oil recovery or oil recycling (Environmental Information, Ltd.).

(d) Waste oils are generally considered unsuitable for disposal by deep-well injection.

(e) In light of the above, incineration is considered the appropriate T/D technology. Further, burning the waste oil as a fuel in a boiler, in which the heat value in the oil is used to produce steam or for heating, is the preferred incineration option.

The following are the degree-of-hazard output data for Waste Stream 31:

WASTE STREAM NO.	31
Genname:	Coal Ash
Proname:	Coal Fired Boilers
Volume:	9,009 Cu. Yd. (39,952,000 kg)
Composition:	Solids - 100%
Toxicity Hazard:	Moderate
Disease Hazard:	None
Fire Hazard:	None, flashpoint is 200 F
Leaching Agent Hazard	Moderate, pH is 11.3
Biological Characteristics Hazard:	None.

Using the above data and the matrix table data, the following is the general reasoning that was used in the TD selection process:

(a) The waste is rated moderate for toxicity and leaching agent hazard, and none for disease hazard, fire hazard, and biological characteristic hazard.

(b) The ash is a solid inorganic material waste, and not amenable to incineration, physical/chemical (P/C) treatment, biological treatment (including land treatment), or deep-well injection.

(c) As there is no need to put the waste into a secure or hazardous waste landfill, the suggested option is to dispose of the waste in an industrial waste landfill or even a sanitary/municipal landfill.

(d) In some instances, coal ash from coal fired utility boilers is stored in above ground piles near the power generating station; this constitutes another possible option.

(e) Another alternative is to try to use the ash in a R/R manner as a component for cement or as fill material for roads or construction projects.

From the above, one can see that the degree-of-hazard output information does provide a valuable tool to assist in the selection of appropriate T/D option(s) for disposal of particular waste streams. Generally similar assessment and reasoning to that described immediately above for Waste Streams 192 and 31 was applied to the T/D technology selection process for the remainder of the 30 wastes studied in detail on this project. The results of this assessment on the selection of suggested T/D technologies or management strategy options are presented for the 30 waste streams.

WASTE STEAM NO.	31
Genname:	Coal Ash
Proname:	Coal Fired Boilers
Suggested T/D Option(s)	(1) Burial in an industrial waste landfill. (2) Possible R/R use as fill material for roads or on construction projects.

WASTE STEAM NO.	34
Genname:	Composite Paint Sludge
Proname:	Drum Cleaning Operation
Suggested T/D Option(s)	Incineration followed by burial of ash in industrial waste landfill.

WASTE STEAM NO.	42
Genname:	Dewatered Lime Sludge
Proname:	Electrogalvinizing Cold Rolled
Suggested T/D Option(s)	Burial in a hazardous waste landfill on an industrial waste landfill.

WASTE STEAM NO.	44
Genname:	Diatomaceous Earth Filter Cake
Proname:	Oil Additive Refining
Suggested T/D Option(s)	(1) Land treatment. (2) Industrial waste landfill.

WASTE STEAM NO.	67
Genname:	Foundry Sand
Proname:	Gray Iron Foundry
Suggested T/D Option(s)	(1) Industrial waste landfill. (2) Sanitary/Municipal landfill.

WASTE STEAM NO.	72
Genname:	Fuller's Earth
Proname:	Filter Fuller's Earth
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	78
Genname:	Grease, Scum, Floatable Material
Proname:	Primary Settling
Suggested T/D Option(s)	Incineration (industrial boiler); ash to industrial waste landfill.

WASTE STEAM NO.	79
Genname:	Grease/Sludge
Proname:	Bakery Waste
Suggested T/D Option(s)	(1) Incineration; ash to industrial waste (IW). (2) Land treatment.

WASTE STEAM NO.	94
Genname:	Kitchen Grease Catch Basin
Proname:	Kitchen Catch Basins
Suggested T/D Option(s)	P/C treatment to separate water from grease, then either burn or bury remainder in an industrial waste landfill.

WASTE STEAM NO.	107
Genname:	Mixed Solid Waste
Proname:	General Cleanup Refuse
Suggested T/D Option(s)	Industrial or sanitary landfill.

WASTE STEAM NO.	112
Genname:	Neutralized Gasoline Cracking
Proname:	Petroleum Refinery - FCC Unit
Suggested T/D Option(s)	Hazardous or industrial waste landfill.

WASTE STEAM NO.	113
Genname:	Neutralized Salts Brine Solution
Proname:	Amines MFG
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	117
Genname:	Oil Contaminated Solids
Proname:	General Refinery
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	124
Genname:	Oily Sludge
Proname:	Heavy Machinery Manufacture
Suggested T/D Option(s)	Incineration (ash to hazardous or industrial landfill).

WASTE STEAM NO.	132
Genname:	Plating Treatment Sludge
Proname:	Plating Wastewater Treatment
Suggested T/D Option(s)	Hazardous waste landfill.

WASTE STEAM NO.	134
Genname:	Poly-Isocyanurate Foam Board
Proname	Foam Board Insulation Mfg.
Suggested T/D Option(s)	Industrial or sanitary landfill.

WASTE STEAM NO.	135
Genname:	Polymer Waste Water
Proname:	Mfg. Chemicals Polymer
Suggested T/D Option(s)	(1) Industrial waste landfill. (2) Incineration (ash to industrial waste landfill).

WASTE STEAM NO.	153
Genname:	Scum From Skimmings
Proname:	Water Reclamation
Suggested T/D Option(s)	(1) Industrial waste landfill. (2) P/C treatment to dewater waste prior to burial of residual waste in an industrial waste landfill.

WASTE STEAM NO.	154
Genname:	Sewage Sludge
Proname:	Wastewater Treatment Plant
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	192
Genname:	Used Oils
Proname:	Waste Oil Pick-up
Suggested T/D Option(s)	(1) Incineration in boiler to take advantage of fuel value of oil; ash to industrial waste landfill. (2) R/R treatment to rerefine oil.

WASTE STEAM NO.	193
Genname:	Vacuum Filter Cake Sludge
Proname:	Municipal Sludge
Suggested T/D Option(s)	Industrial or sanitary/municipal landfill.

WASTE STEAM NO.	211
Genname:	Waste Oil
Proname:	Waste Oil
Suggested T/D Option(s)	(1) Incineration (ash to industrial waste landfill). (2) Industrial waste landfill. (3) P/C treatment to dewater waste prior to incineration.

WASTE STEAM NO.	244
Genname:	Waste Oil Tank 2-6
Proname:	General Production
Suggested T/D Option(s)	(1) Incineration (ash to industrial waste landfill). (2) Industrial waste landfill.

WASTE STEAM NO.	260
Genname:	Water and Oil Waste
Proname:	Steel Stamping
Suggested T/D Option(s)	(1) Industrial waste landfill. (2) P/C treatment to dewater prior to incineration or burial in an industrial waste landfill.

WASTE STEAM NO.	51e
Genname:	Foundry Sand
Proname:	Moding Process
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	59e
Genname:	Incinerator Ash
Proname:	Incinerator
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	79e
Genname:	Metal Hydroxide Sludge
Proname:	Electroplating
Suggested T/D Option(s)	Industrial waste landfill.

WASTE STEAM NO.	98e
Genname:	Oil and Water Waste
Proname:	Coolant From Machinery
Suggested T/D Option(s)	(1) Industrial waste landfill. (2) P/C treatment to dewater waste prior to incineration or burial of remaining waste in an industrial landfill.

WASTE STEAM NO.	151e
Genname:	Paint Sludge
Proname:	Spray Booth Painting
Suggested T/D Option(s)	(1) Industrial waste landfill. (2) Incineration (ash to industrial waste landfill).

WASTE STEAM NO.	330e
Genname:	Wastewater Treatment Sludge
Proname:	Wastewater Treatment System
Suggested T/D Option(s)	Industrial or sanitary/municipal landfill.

7.0 CONCLUSIONS

7.1 Feasibility and Value of the Classsification System

In Chapter 4, certain criteria are presented to guide the development of the Special Waste classification system. These system criteria are as follows:

- Capable of assessing degree of hazard with the goal of matching outcomes to disposal options
- Comprehensive in terms of breadth of waste characteristics considered
- Emphasis on toxicity
- Reliance to the maximum possible extent on use of waste stream information in files of the State of Illinois as well as other sources
- A preliminary screening process followed by a more detailed evaluation
- Capable of making distinctions or discriminations among waste streams
- Final classification consisting of several distinct outputs which clearly identify the types of hazard, as opposed to a summary score that combines differing waste characteristics.

The underlying question regarding the feasibility of developing a degree of hazard classification system can be simply stated: is the system capable of discriminating meaningfully among the Special Waste streams?

In order to answer this criteria, it is necessary to review the results from applying the classification system to selected Special Waste

streams, described in Chapter 5 of this report. The study team selected 238 waste streams to be evaluated solely with the screen and 30 waste streams with the comprehensive Degree of Hazard evaluation. The 238 waste streams were selected using the following criteria:

- High volume waste streams
- High toxicity waste streams
- Low or minimal toxicity or hazard
- Frequently cited problem waste streams

Although the sample of waste streams are not statistically representative of the various types of Special Waste streams, they do not include the major types. Perhaps the major caveat is that definitive conclusions cannot yet be drawn regarding the totality of Illinois Special Wastes.

7.1.1 Summary of Screen Results

The following table presents a summary of the results of the testing out the screen, which is step 1 in the classification system.

Number of "Yes" Answers that Trigger Entry to Degree of Hazard	Number of "Unknown" Answers That Could Trigger Entry to Degree of Hazard	Number of All "No" Answers That Lead to Illinois Review Box
137	100	1

This table shows that the screen triggered 137 "yes" answers, 100 "unknown" answers, and 1 "no" answer. Most of the 137 waste streams with "yes" answers were triggered by the carcinogen question.

The IEPA data for one hundred waste streams did not have sufficient information to define toxicity or make other screening decisions, and therefore, were scored as unknowns. Under the rules of the screening procedures, these waste streams were sent to the Degree of Hazard Evaluation. Only one waste stream (latex waste effluent) received no's on all questions and could be considered as a minimal hazard waste stream. Normally, to conduct degree of hazard evaluation, additional information will be acquired.

7.1.2 Summary of Degree of Hazard Evaluation

Table 5-6 provides a summary of the 30 waste streams tested for the Degree of Hazard Evaluation including names, volumes and the accumulative toxicity and environmental fate and respective scores. This table shows that the classification system has the ability to discriminate among the waste streams because there were examples of all four categories. Waste steam 44 (diatomaceous filter cake), 107 (mixed solid waste), 135 (Polymer waste water) and 4 others were of negligible risk. By contrast, waste stream 34 (composite paint sludge), 132 (plating treatment sludge), and 192 (used oils) and 9 others received a high risk. There were 5 streams with moderate risk and 3 with low risk. Another 3 had inadequate information to develop the scores.

What can be concluded from these results is that the classification by degree of hazard system accomplishes its intended purpose: it does discriminate among various types of waste streams.

7.2 Assumptions and Limitations

In this section, some of the major assumptions and limitations of the Special Waste classification system will be discussed.

7.2.1 The Screen

The screen is designed to quickly determine whether a waste stream is innocuous or requires a comprehensive Degree of Hazard Evaluation. If information is not available on one of the screening criteria, then the waste stream automatically goes to the more detailed and comprehensive Degree of

Hazard Evaluation. These aspects of the screen point out its basic conservatism; it is designed to ensure that no waste stream with even the slightest potential hazard to human health or the environment slips through the classification system without the benefit of a detailed evaluation. The underlying assumption was that the purpose of the classification system is to refine the ability of the regulatory process to discriminate among waste streams so as to avoid unnecessary costs while enhancing the protection of human health and the environment. Given this conservative approach, therefore, any Special Wastes that pass through the screen are truly "minimal" hazards.

7.2.2 Complexity of the System

The complexity of the classification system is critical to its potential usefulness. The complexity depends on the number of steps as well as how they are interrelated. Having as simple a system as possible is important because the ability of waste generators and regulators to actually use the system depends on its simplicity. However, an overly simple system may not improve upon the existing process of the Special Waste classification. Consequently, a balance must be struck between complexity and simplicity.

In the proposed system, the screen was designed to be relatively simple: a large number of screening criteria was looked at but there was no attempt to combine them or evaluate the combined effects of the various waste stream components. In the Degree of Hazard Evaluation, on the other hand, there was an attempt to look at the combined toxicity of various components and also to summarize different criteria within the overall toxicity hazard evaluation. The equivalent concentration formula was adopted from the Washington State model to provide a method to evaluate, using weighted sums, the combined toxicities of all the components that exhibit any degree of toxicity. Also, the overall toxicity evaluation provided a summary ranking of various types of toxicity and environmental fate properties (bioaccumulative, persistence and mobility). The final Degree of Hazard Evaluation, however, did not attempt to combine or summarize the ranking of the other five factors (disease, fire, leaching agent and biological) with the toxicity hazard. In contrast, other classification systems such as the State of Michigan's system do provide for a summary score. In conclusion, a system

was designed that balances complexity and simplicity, keeping in mind that the goal of the system was the ability to discriminate adequately among waste streams.

7.2.3 Migration or Mobility of Toxic Components

One possible objection to the Degree of Hazard Evaluation may be whether it adequately addresses the chemical or physical mobility of the toxic waste stream components. A waste generator could say, for example, that a waste stream contains a certain amount of toxic constituents but that they are chemically or physically bound up so as to prevent them from being released into the environment. Does the proposed system address this? First, substances with less than the highest degree of toxicity are evaluated using the environmental fate factors (bioaccumulative, persistence, solubility) which may modify the significance of the toxicity. The solubility addresses, at least in part, whether a chemical compound can actually be leached from a landfill. This test is not, however, the same as the leaching test under RCRA, the EP toxicity test. Substances which receive the highest toxicity ranking, however, automatically receive the highest overall toxicity score, regardless of the mobility.

7.2.4 Weight/Concentration Scoring

In the overall toxicity evaluation, a graph is used to evaluate the significance of the total weight and equivalent concentration levels of the toxic components in a waste stream. The graphs (Figures 4-6, 4-7, and 4-9) are used in evaluating the toxicity and environmental fate of the toxic components of each waste stream. Looking at these graphs, it should be evident that where the lines are drawn largely determines the final toxicity hazard rank. In this study two approaches were considered in determining the location of the ranking lines. One assumption was to use the established federal PCB standards; the other was to draw the lines arbitrarily using the best professional judgment as to how many waste streams are, in fact, hazardous. The study team concluded that these approaches were the best ones available within the constraints of the study. It would be desirable to rationalize the placement of the lines as much as possible in terms of a risk analysis

and existing state or federal standards. Given the inherent uncertainties and importance of the graphs, the interested parties should participate in determining the best method to finalize the graphs.

7.2.5 Use of Bioassay on Disputed Cases

Washington State allows a generator to conduct a bioassay test of the waste stream. If a bioassay shows the waste stream to be below the toxicity levels indicated by the classification system using published data on toxicity, then the waste stream may be reclassified as less hazardous or even receive a waste class designation that allows unmonitored landfilling. The issue may become critical if specific regulations are considered. The importance of this issue is underlined by the current debate at the federal level on the adequacy of the EP toxicity test.

7.3 Findings

Following are some of the significant findings and observations the study team made in the conduct of this study:

7.3.1 Regulatory Trends

- There is a trend towards the expansion of federal regulations of industrial wastes not presently covered by RCRA or other federal laws.

- The 1984 RCRA amendments require the refinement of the testing and classification procedures for hazardous wastes, and may eventually require more accurate and comprehensive data on waste streams.

7.3.2 Adequacy of Data

- Data collection requirements in IEPA's regulatory program in theory provide adequate information for implementation of the proposed degree of hazard classification system. For some waste

streams, however, implementing the system would require collection of additional information not presently required;

- The existing data in IEPA files for the waste disposal permit applications, manifests and annual reports provide more accurate and complete data for RCRA hazardous waste streams than for non-hazardous waste streams.

7.3.3 Waste Stream Characterization

- Waste streams with similar hazardous characteristics/properties have been observed to be classified sometimes as hazardous and sometimes as non-hazardous.

- A detailed analysis of manifest data suggest that significant volumes of special wastes presently disposed of on-site as non-hazardous may have hazardous properties.

7.4 Recommendations

At this point it is not possible to draw definitive conclusions regarding the classification of Special Waste streams by degree of hazard. In order to do this, it will require refinement of the classification system and an analysis of all of the waste streams or at least a statistically significant sample of them. Clearly, the results of the system, that is, how much of the wastes become classified as hazardous, depend on a number of assumptions, many of which were discussed earlier in this report. Although the study team provided a scientific basis in setting standards regarding the various hazard criteria, the best science currently available leaves a large area of uncertainty. The debate over carcinogenicity, how safe is safe, acceptable levels of risk, etc., will continue to make it difficult to fall back on purely scientific rationale. Finally, it must be recognized that the classification system is only a tool that provides a framework for decisions regarding the acceptable levels of risk. These decisions must be based in part on the best judgements by the affected parties in this issue.

If the state is interested in implementing such a classification system, then the following recommendations should be considered:

- The state should continue the current level of data requirements for special wastes and insure that such reporting requirements are sufficiently fulfilled in order to provide a basis for an accurate assessment of the waste streams. These data are needed to determine the hazardous properties of special wastes.

- The proposed classification system is a workable system. Further refinements are needed with attention to the specific issues and assumptions discussed in this report.

- The state should complete the development of this classification system by conducting an evaluation of the degree of hazard of waste streams and examining the economic implications of implementing such a system.

APPENDIX H

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APPENDIX I

REVIEW COMMENTS RECEIVED

In July 1985, the draft version of this report was distributed to parties representing a broad range of public and private interests. Review comments were invited. On October 7, DENR held two public meetings for the purpose of explaining the classification system and receiving comments.

Appendix I contains:

1. Pages (E-14, 7-7, and 7-8) appearing in the draft version of this report that were subsequently changed in this final report as a result of oral and written comments received by DENR from interested parties.

2. All written comments received by DENR on the draft version of this report.

conclusions to be made about the total universe of Special Waste streams because neither the 238 nor the 30 waste streams are statistically representative of all Special Wastes.

In the conduct of this study, certain assumptions were necessary. In designing a workable (degree of hazard classification) system, a balance had to be struck between the value of simplicity and the need for complexity. If a system is too simple, it cannot adequately discriminate among the waste streams; if it is too complex, no one will be able to use it in real life situations. Finally, it must be recognized that the classification system is only a tool that provides a framework for decisions regarding the acceptable levels of risk. Science can only go so far. The final decisions must be based in part on the best judgments made by the affected parties in this issue.

Recommendations

If the state is interested in implementing such a classification system, then the following recommendations should be considered:

- The state should continue current level of data requirements and improve the accuracy and completeness of the data provided to IEPA in the permitting process.

- The state should continue the supplemental permit requirement because it provides data needed to determine the hazard properties of special wastes and provides for adequate regulation of the wastes. Such data also provides a record of the disposition of the wastes which in the future may prove to be hazardous.

- The proposed classification system is a workable system, but it needs to be modified or refined with attention to the specific issues and assumptions discussed in this report.

7.3.3 Waste Stream Characterization

- Waste streams with similar hazardous characteristics/properties have been observed to be classified sometimes as hazardous and sometimes as non-hazardous.

- A detailed analysis of manifest data suggest that significant volumes of special wastes presently disposed of on-site as non-hazardous may have hazardous properties.

7.4 Recommendations

At this point it is not possible to draw definitive conclusions regarding the classification of Special Waste streams by degree of hazard. In order to do this, it will require refinement of the classification system and an analysis of all of the waste streams or at least a statistically significant sample of them. Clearly, the results of the system, that is, how much of the wastes become classified as hazardous, depend on a number of assumptions, many of which were discussed earlier in this report. Although the study team provided a scientific basis in setting standards regarding the various hazard criteria, the best science currently available leaves a large area of uncertainty. The debate over carcinogenicity, how safe is safe, acceptable levels of risk, etc., will continue to make it difficult to fall back on purely scientific rationale. Finally, it must be recognized that the classification system is only a tool that provides a framework for decisions regarding the acceptable levels of risk. These decisions must be based in part on the best judgements by the affected parties in this issue.

If the state is interested in implementing such a classification system, then the following recommendations should be considered:

- The state should continue current data requirements and improve the accuracy and completeness of the data provided to IEPA in the permitting process.

- The state should continue the supplemental permit requirement because it provides data needed to determine the hazard properties of special wastes and a provision for adequate regulation

of the wastes. Such data also provides a record of the disposition of the wastes which in the future may prove to be hazardous.

- The proposed classification system is a workable system, but it needs to be modified or refined with attention to the specific issues and assumptions discussed in this report.

Illinois Manufacturers Association

August 13, 1985

Ms. Wendy J. Garrison
Research Scientist
Illinois Department of Energy and
  Natural Resources
State Water Survey Division
P.O. Box 5050, Station A
Champaign, Illinois 61820

Dear Ms. Garrison:

I have reviewed the draft of the "Special Waste Categorization Study" (Project No. HWRIC 007). I am disturbed by the draft recommendations, which boil down to maintaining (or even increasing) the paperwork/analysis burden on waste generators which results from the "special waste" — supplemental permit — manifest system.

The report does not appear to consider the costs to industry of the Illinois system which is far more comprehensive than the federal RCRA system. Illinois manufacturers cannot afford additional state-imposed costs — for permits, analyses, and added treatment and disposal costs — unless there is a compelling need. The report indicates that of the 30 selected "special" wastes, 12 had a high degree of hazard, five a moderate degree of hazard, ten either low or negligible hazard, and three unknown.

Can it be that one-third of all "special wastes" should be deregulated?

Waste streams which are not hazardous should be classified as refuse, not as "special" waste. The costs to Illinois industry must be considered in any report dealing with "special" waste.

Lest I sound too negative, the report appears to be an excellent analysis of various methods of categorizing wastes as to degree of hazard. If the analytical work were performed on all Illinois "special" waste streams by the state, and the results published, it would serve as a guide to industry and others as to waste hazard (and non-hazards).

Sincerely,

Tom Reid

Thomas L. Reid, Vice President
Educational & Environmental Services

TLR/ed

cc: K.R. Reddy
    D. Ramsay

175 W. Jackson Boulevard, Chicago, IL 60604 (312) 922-6575
Springfield Office 300 W. Edwards Street Springfield, IL 62704 (217) 522-1240

Illinois Environmental Protection Agency · 2200 Churchill Road, Springfield, IL 62706

217/782-6761

August 23, 1985

Wendy J. Garrison
Research Scientist
HWRIC
P. O. Box 5050, Station A
Champaign, IL 61820

Dear Ms. Garrison:

Re: Draft Report on Special Waste Categorization Study, HWRIC 007

Thank you for the opportunity to comment on this HWRIC draft report. As you know, I have been involved with explaining the Agency's data base and making the waste stream data available to the HWRIC contractor/investigator from the project's inception. I was looking forward to a classification system for non-hazardous special waste that would help the Agency draw conclusions about the effectiveness of our program; unfortunately, this draft report does not appear to be useful to the Agency.

The major drawback to this classification system is its complexity. While the Agency certainly has the capability to perform more complicated categorizations (although the number or reviews could be staggering), determining the rules' applicability starts with the generator. When the generator is a major corporation with an environmental engineering department, the proposed system could work; when it is a gasoline service station, a local dry cleaners, or a plating job shop, the proposed hazard ranking will simply be beyond its capabilities. I'm afraid that this will lead to even greater confusion about special waste than exists today.

The proposed classification system requires that each component of a waste stream be considered in the ranking. Each generator will need to analyze each waste stream to determine the exact amount of each possible chemical component in the wastes to do the ranking. It will be nearly impossible for the Agency or the regulated community to keep abreast of which components should be analyzed for and the day-to-day changes in toxicity information based on new research. There are too many waste streams and too many possible waste components.

Page 2

The other major disappointment of the study is the limited analysis of the waste streams. A study of how many waste streams (or how large a volume) are expected to pass the initial screen or be classified in each hazard ranking would be meaningful to determine what the Agency should expect in reviewing future waste stream permit applications.

Sincerely,

Michael F. Nechvatal, Manager
Compliance Monitoring Section
Division of Land Pollution Control

MFN:tk:2/1/45

cc: Rom Reddy, DENR
Division File
Bob Kuykendall, IEPA
Harry Chappel, IEPA

cc'

ILLINOIS HOUSE OF REPRESENTATIVES
OFFICE OF THE SPEAKER

AM
7,8,5,

Staff
...
62706

August 26, 1985

Mr. Don Etchison, Director
Department of Energy and
Natural Resources
325 West Adams
Springfield, Illinois 62706

Dear Don:

I have recently reviewed the final draft report for the "Special Waste Categorization Study" that the Department was mandated to perform pursuant to House Bill 3193, the "Currie bill" of last session. Representative Currie and I are pleased with the outcome of the study. The Department and the contractor are to be congratulated on completing such a sophisticated and thorough product in such a timely manner. The proposed waste classification scheme is exactly what we envisioned as the outcome of this legislation.

This report, however, is just the first step toward evaluating the "degree-of-hazard" approach to regulating industrial wastes. It appears as though the next step needs to be to run a complete year's data on all Illinois waste streams through the system to see how these wastes would fall under the scheme. Completing the treatment/disposal method assessment for the waste streams would also be very beneficial, especially in implementing the Senate Bill 171 ban on landfill disposal of hazardous waste that will take effect in 1987.

Representative Currie, along with representatives of several environmental groups, are very interested in seeing that the work that has been started on the "degree-of-hazard" approach be continued. We are interested in the Department's plans to make funding available to continue the necessary follow-up studies. If no such internal funding is planned at this time, we would appreciate the Department's estimate of the costs of performing these next two tasks to be reconsidered as a possible supplemental appropriation. Any other suggestions by the Department regarding the most effective manner to proceed on this issue would also be welcome.

Mr. Don Etchison
Page 2
August 26, 1985

I look forward to working with you in furthering the outcome of this work.

Sincerely,

Bob Swain

BOB SWAIN
House Democratic Staff
Room 528 -- Statehouse
Springfield, IL 62706

(217) 782-4817

BS:mm

October 3, 1985

Ms. Wendy J. Garrison
Research Scientist
Illinois Department Of Energy
& Natural Resources
State Water Survey Division
P.O. Box 5050, Station A
Champaign, Ill. 61820

Dear Ms. Garrison:

The IMA Hazardous Waste Task Force has reviewed the final draft of the "Special Waste Categorization Study" and is impressed by the in-depth analysis of the various methods of categorizing wastes. The Task Force is concerned about the recommendations filed with this report and the follow-up of these recommendations.

The concerns are:

1. The categorization study recommendations do not allow for the deregulation of "negligible or low hazard" special wastes. The continued inclusion of these types of waste in the special waste category is an unnecessary burden both for industry and the agency. The solution is to recommend a means of moving special wastes to the category of refuse.

2. There is no cost analysis associated with this classification system to take into account the additional economic burden that this system may impose. The tests and/or research in this study will significantly increase the costs of doing business in Illinois for all.

3. Finally, the report does not utilize the concern that this approach is not consistent with other states in this region. Any use of this document should be for guidance in the deregulation of wastes for developing appropriate disposal alternatives. Efforts to expand the lists of hazardous wastes should be consistent with the already existing RCRA requirements.

It is our opinion that the recommendation section should encompass these concerns to complete the intent of Public Act 83-1268.

Sincerely,

Kenneth J. Willings

Kenneth J. Willings
IMA Hazardous Waste
Task Force - Chairman

bkw

Citizens For A Better Environment

October 9, 1985

Ram Reddy
Energy and Environmental Affairs Division
Department of Energy and Natural Resources
325 W. Adams St.
Springfield, Illinois 62706

Dear Mr. Reddy:

The following are comments of Citizens for a Better Environment concerning the Department of Energy and Natural Resources' draft Special Waste Categorization Study. CBE would like to commend the Department and its consultants for preparing a very credible report. It lays the groundwork for revising the special waste classification system in Illinois in an environmentally sound manner.

We agree with the report's recommendation that the supplemental (or special waste) permit system be continued and upgraded since it can provide data on the specific chemical components in individual waste streams. While the completeness and accuracy of the data must be improved, it is needed to characterize the hazardous properties of special wastes, as outlined in the report.

This classification process will help the state to focus its resources on hazardous waste streams that fall outside the federal regulatory system. As you know, the U.S. EPA regulations implemented under the Resource Conservation and Recovery Act only cover a limited number of specific waste streams from particular industrial processes. Many waste streams that contain significant quantities of toxic compounds such as acrylonitrile have not been designated as "hazardous" because they are not generated by a specific listed process.

This creates a problem because such wastes can be disposed of in an ordinary landfill even though they may pose an equal or greater threat to human health than RCRA listed hazardous wastes which must be sent to a specially-designed facility. Since the report's classification system is designed to characterize wastes by degree of hazard, the state can more carefully tailor its regulatory requirements to ensure that all hazardous wastes are being properly disposed of and/or treated.

Sincerely,

Kevin Greene

Kevin Greene
Research Staff

cc: Wendy Garrison, Hazardous Waste Research
and Information Center

[redacted]ninistrative: 312-939-1984/Research: 312-939-1530
506 South Wabash Ave. / Chicago, Illinois 60605

DEERE & COMPANY

JOHN DEERE ROAD, MOLINE, ILLINOIS 61265 U.S.A

Safety, Environment
& Energy Management

9 October 1985

Dr. Gary D. Miller
Assistant Director
Hazardous Waste Research & Information Center
Department of Energy and Natural Resources
501 South Sixth Street
Champaign, IL 61820

Comments on
Final Draft Report
Special Waste Categorization Study
Project #HWRIC 007

Dear Dr. Miller:

Deere & Company takes this opportunity to offer comments on the above subject study for your consideration. We believe that, viewed as a pure effort at waste categorization, the study has merit and should serve as a good starting point for the development of a waste management system based on degree of risk. Unfortunately, the practical impacts of how such a study may be used or abused in the process of implementation and regulatory codification are probably far more important than the specifics of the classification scheme itself. It is in this area of implementation that the study is most weak and most subject to abuse. It is in this context that we offer our comments.

In spite of certain philosophical statements to the contrary, we feel that the system as proposed is heavily biased toward consideration of chemical constituents (quantity and toxicity) present in a waste as the determining factors in degree of risk evaluations. We believe that release characteristics under reasonably anticipated disposal/treatment options should be equally central in the schema. As an example, consider a cured paint waste containing lead and chromium but with the toxic metals fully encapsulated in the resins. The intrinsic hazard of such a waste may be very low even though the metals content may be relatively high. Another example is foundry sand where some small quantities of leachable material may be present, but where common practice is disposal in a monofill in essentially neutral pH conditions. We believe that without addressing these "as disposed" issues there will be a decided tendency to overclassify certain wastes. Conversely, some otherwise low risk wastes traditionally disposed in "the garbage" may deserve greater environmental concern than revealed merely by their constituents.

DEERE & COMPANY

Dr. Gary D. Miller
9 October 1985
Page 2

We are also concerned that the initial screen by which wastes are eliminated from further analysis is overly fine, causing most wastes to require a full blown degree of hazard evaluation. There is a need to find a way to allow more wastes out of the system (or at least into their proper classification slot) earlier in the process and with less cost and effort. The trade off here may be to make the initial screen a slightly more complex procedure in order to obtain more useful results quickly. At the other end, the degree of hazard evaluation should have more "escape routes" directly to a decision point. For example, a waste clearly intended for incineration or recycle should not require biological testing for its proper classification.

We note that DENR has recommended retention of the supplemental permit system in Illinois. This aspect of current regulations has been controversial in the past and will be subject to debate in the IPCB hearings on R84-17. We do not believe anything in your study justifies this recommendation since the need to maintain and improve the level of data available on waste streams is adequately addressed in your first recommendation. We would hope that the second recommendation dealing with the supplemental permit system can be eliminated as irrelevant and because it begs a regulatory question.

We note that the result of this classification scheme is to (hopefully) divide all wastes into four hazard categories; i.e., high, moderate, low and negligible. It is important to understand what this implies in terms of treatment/disposal options, costs and possible regulatory language. How will a "low" or "moderate" waste be treated differently than one which is "high"? What difference is justified? What practical environmental risk is involved in treating these wastes differently? If the classification scheme results in no real change in requirements, provides no greater risk protection or administrative and financial relief, then one must question its usefulness.

We note that DENR apparently does not see this report as its final product, but is seeking additional funding for a second phase of the project. We would hope that DENR will carefully annotate the current document to indicate clearly what this study does and does not provide, how it is to be used and how it should not be used, and what issues remain to be resolved and their significance.

We appreciate DENR's willingness to consult with the concerned public on this study and hope our comments are useful in your process.

Yours truly,

John E. Smith

John E. Smith
Environmental Control

JES/b
c: M. E. McGuire/R. D. Grotelueschen, S. Marder (ISCC), T. Reid (IMA)

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JOHN P. HANNA
OF COUNSEL

October 10, 1985

Mr. Gary Miller
Illinois Department of Energy
and Natural Resources
525 West Adams Street
Springfield, IL 62706

RE: Special Waste Categorization Study, Project No. HWRIC 007
Comments

Dear Mr. Miller:

On behalf of our clients, Granite City Steel Division of National Steel Corporation; Interlake, Inc.; LTV Steel Company; Laclede Steel Company; Northwestern Steel and Wire Company; and United States Steel Corporation, we hereby submit the following comments on the Final Draft Report on the Special Waste Categorization Study. We wish to thank you for the meeting of October 7, 1985, at which the purpose and scope of this report was discussed with representatives of industry, government, and citizens' organizations. By these comments, we wish to confirm our understanding of the purpose, scope, and results of this study. We understand that:

1. The study undertaken by the Department of Energy and Natural Resources did not address the issue of whether a classification system for special waste should be developed or put into place. Since this study was undertaken pursuant to a legislative mandate, the appropriateness and desirability of such a system was not addressed at all but was assumed for purposes of current activities.

2. The study undertaken did not, at this point, address the question of economic or technical feasibility of the hazardous classification scheme proposed. The cost and feasibility of such a scheme would have to be addressed in subsequent studies.

ROOKS, PITTS AND POUST

Mr. Gary Miller
October 10, 1985
Page Two

3. The study undertaken and the report which resulted are not intended to be incorporated into regulations or to be the basis of any regulatory proposal at this time. Specifically, the hazard ranking system was not intended to be adopted as a rule either by the legislature or the Pollution Control Board. The necessary policy decisions concerning implementation of any ranking system for special waste have yet to be addressed.

4. The question of whether special waste should be kept as a category and what should be included within it was not considered within the course of this study. Again, because of the legislative mandate, this study assumed the present Illinois special-waste category.

5. The "recommendations" contained at page E-14 with respect to continuing certain permitting requirements are solely for the purpose of continuing to gather data which will allow the Department of Energy and Natural Resources to complete its evaluation of special-waste categorization and are not intended to be any permanent regulatory recommendations.

We understand that the above clarifications will be included in an amended preamble to the study to avoid any confusion in the legislature or the public mind concerning its scope, purpose, or results. We also understand that the Department is considering a further study to address the issues of cost, feasibility, and implementation. These commentators do not oppose such further study so long as it does not attempt to employ the classification scheme contained in the present report to actually classify all Illinois special wastes. The issue of whether the classification scheme contained in this report is a valid one, or whether the weightings proposed therein are valid, remains open.

In addition, we wish to point out that there has not been a detailed technical review of the actual categorization contained in the study, and we are not at this time in a position to comment on it beyond those comments presented at the meeting. The issues raised at the meeting, including consideration of disposal options earlier in the process, consideration of the special-waste screen, etc., remain to be addressed.

Again, we thank you for the opportunity to confer with you on October 7, 1985.

Very truly yours,

Jim

James T. Harrington

JTH/li

cc: K. R. Reddy

ISCC

Illinois State Chamber
of Commerce

215 East Adams Street
Springfield, Illinois 62701
217.522.5512

RECEIVED
OCT 17 1985

October 11, 1985

Mr. Richard P. Moffa
Principal Research Scientist
Resource Management &
Economic Analysis Department
Battelle Columbus Laboratories
505 King Avenue
Columbus OH 43201

RE: Special Waste Categorization Study

Dear Mr. Moffa:

The Illinois State Chamber of Commerce (ISCC) appreciated the opportunity to discuss the subject study and offers the following comments:

1. As regards the overall concept, it is apparent that the screening and analysis mechanisms proposed are more exhaustive than required under RCRA. With the basis that the wastes to be evaluated are of lower hazard than RCRA wastes, it is necessary to question the need for such a rigorous system.

   The ISCC has often stated that if the RCRA selection (or hazardous ranking) system is not all inclusive, a system should be developed to identify those additional wastes which should be given the same overall attention as RCRA wastes. This process is ongoing and perhaps such a selection system would be the ultimate utility of the subject study.

2. The study must identify, at the outset, the overall degree of hazard of the waste universe it is addressing. It should be made clear that the entire proposed system deals with a set of wastes which by definition are less hazardous than RCRA.

3. On Page E-14, the recommendation dealing with supplemental permits is not consistent with the scope of the report. The supplemental permit system is extremely cumbersome and does not provide any information to the IEPA. The ISCC strongly recommends that this policy recommendation be deleted from the report.

4. Our overall concern with the system is the impression it leaves that an environmental insult will occur unless substantial charges are made in the disposal or treatment of special wastes. The report is based on increasing or decreasing levels of hazard, but no where is the

actual environmental consequence tied to the degree of risk. For example, RCRA regulates wastes at greater than 2 pH or less than 12.5 pH. This range was agreed to after a great deal of negotiation and research. The subject proposes to expand the range to greater than 4 pH or less than 10 pH. The issue is not really what the range is, but rather what affirmative actions would be necessary if the waste exhibited this characteristic. The same can be said for acute toxicity values. In the rationale the report states: "The criteria proposed for use in an Illinois system are adopted from the Washington regulations using a conservatively low toxicity value to catch even a slight toxic effect."

The net result is that the term acute toxicity is defined as anything with the slightest toxic effect.

While the ISCC recognizes that the purpose of the study was to develop a ranking system rather than selecting ultimate disposal based on the ranking system, in some ways the two cannot be divorced. Unless a clear foundation of what environmental risk means is determined, emotion will lead us to overregulation of relatively non-hazardous wastes. Such an outcome is counter-productive and in no one's best interest.

Accordingly, our major comment is that the report make a special effort to lay the groundwork for understanding the baseline from which you are working.

I or any other representatives of the State Chamber would be glad to discuss this matter further if you wish. Once again, thank you for allowing us this opportunity to comment.

Sincerely,

Sidney M. Marder
Environmental Consultant

SMM:tjp

cc David L. Thomas, Hazardous Waste Research & Information Center
Ram Reddy, Department of Energy & Natural Resources
David Ramsey, Department of Energy & Natural Resources